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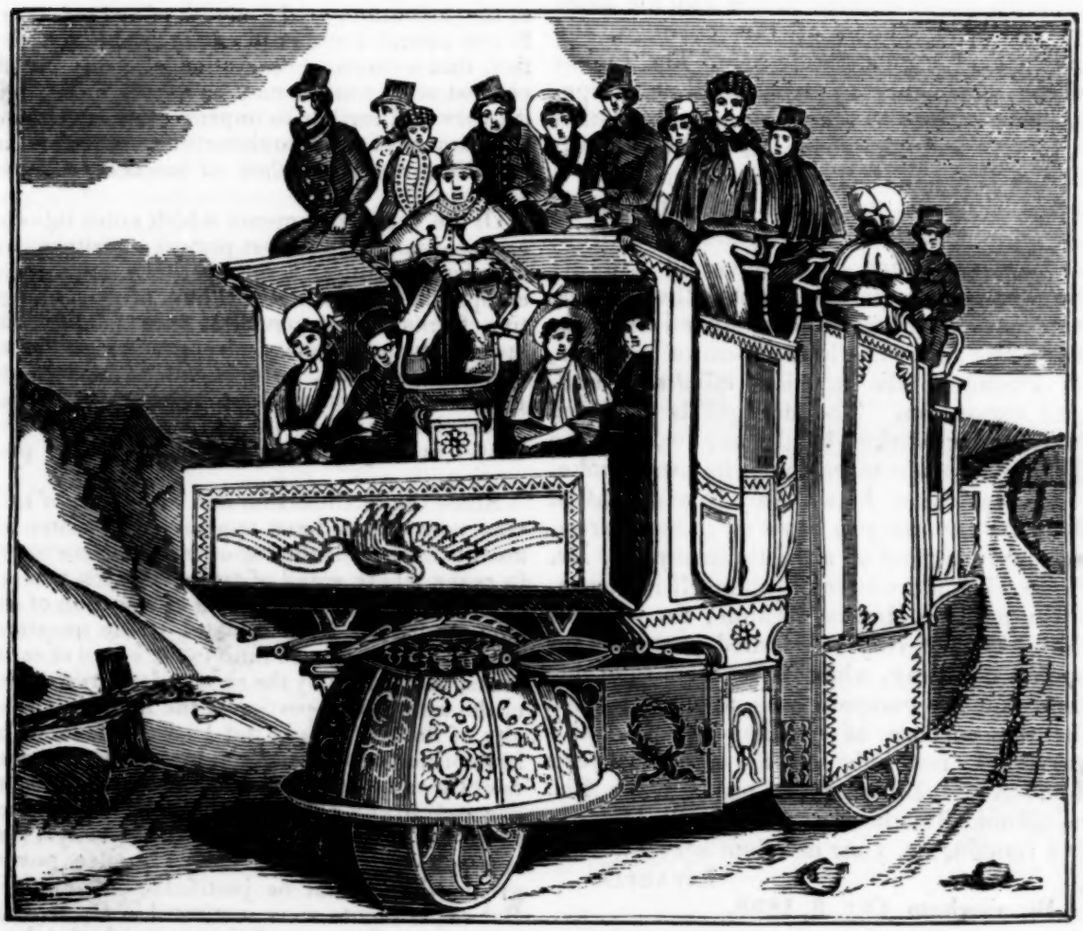
Whatever tends to enlarge the range of observation, to add to the store of facts, to awaken the reason, and to lead the imagination into agreeable and innocent trains of thought, may assist in the establishment of a sincere and ardent desire for information, and may prepare the way for the reception of more elaborate and precise knowledge, and be as the small optic glass called "the finder," which is placed by the side of a large telescope to enable the observer to discover the star which is afterwards to be carefully examined by the more perfect instrument.—[SOCIETY FOR DIFFUSION OF USEFUL KNOWLEDGE.]



DR. CHURCH'S STEAM CARRIAGE.—We introduce to the notice of our readers a view of a carriage in actual operation in England, with the following remarks from the London Mechanics' Magazine:

In the able article on "Inland Transport," in the Edinburgh Review, said to have been written by Dr. Lardner, Dr. Church's carriage is spoken of as one of the likeliest to be attended with success. Feeling persuaded that you can have no wish but to make the claims of every competitor in this arduous field of mechanical discovery equally known to your numerous readers, and attributing, therefore, to accident entirely, your past neglect of those of Dr. Church, I forward with this a drawing of his engine, in the hope that it may be favored with an early place in your pages, along with the follow-

ing explanatory particulars. The drawing, I should observe, is a reduced copy from a very handsome engraving, recently published here by an artist of the name of Lane.

In the cases of Gurney, Heaton Brothers, and also, I believe, Sir Charles Dance, there is one carriage to carry the engine, and another the passengers. These locomotive machines, in short, are *drags*, merely meant to be used in the same way as Jonathan Hall in the infancy of steam navigation proposed to use steam tugs. Dr. Church, on the contrary, has but one carriage for both machinery and passengers. The one represented in the drawing is built to carry fifty passengers. The wheels are about six inches broad in the tire and eight feet in diameter.

The crank shaft, worked by the cylinders, is connected by endless chains with the axles of the hind wheels of the carriage, and each wheel has a separate axle. The spokes of the wheels are so constructed as to operate like springs to the whole machine—that is, to give and take according to the inequalities of the road. The boiler consists of a series of double tubes, one within the other, placed in a vertical position around a circular fire-place, and communicating with it; the heated air passes through these tubes, which are every where surrounded with water. The tubes are in the form of syphons, to counteract the injurious effects of unequal expansion. The draught is produced by a fanner worked by the engine, and the furnace is made to consume its own smoke.

In conclusion, I have only to add, that, if there be any thing to boast of in the patronage and support of a public company, Dr. Church has more to say for himself in this respect than the Messrs. Heaton; for whereas they have but very late issued proposals for such a company, while it is a considerable time since a company was actually formed for the purpose of working Dr. Church's carriages, not only on the road between London and Birmingham, but between Birmingham, Manchester, and Liverpool.

I remain, sir, your obedient servant,

IMPARTIAL.

Birmingham, Oct. 3, 1833.

Mr. Burden's New Steamboat. By G. [Communicated for the Mechanics' Magazine, and Register of Inventions and Improvements.]

It is interesting to observe, as we sometimes may, how nearly the extremes of the perfection of science, and the early rude essays of art, approximate each other; how often, when the efforts of genius, after long and painful study and experiment, have produced a work which excites wonder and admiration, we may find among some of the earliest and rudest specimens of savage or untutored art, an example of the successful application of the principle by men whose minds were never admitted even to the vestibule of the science, and which has existed in the view of half the world for ages, without ever having been known to arrest the eye of science with reference to the particular principle sought for.

I was led to this remark by the notice I have seen in the Journal of Mr. Burden's newly invented steamboat, the principle of which seems to be so far in advance of all others heretofore known, that perhaps we might conclude that attempts at further improvements would be vain. It is indeed, so far as I can judge from the descriptions I have yet seen, a highly important improvement, and Mr. Burden deserves much credit for his sagacity, enterprize, and perseverance; and the remark with which this article is introduced was far from being designed to detract from the merits of the invention, or the credit of the inventor. It was intended rather to excite attention to the fact, that a careful observation of many of the earliest essays of art may be useful in any endeavors still further to improve this important department of naval architecture, as well as in assisting the researches of science on other subjects.

Of the various elements which enter into the composition of the most perfect specimens of naval architecture, some are, in a degree, incompatible with others. Thus, of the respective forms of construction best adapted for speed, burthen, safety, strength, or power of control, severally, no one can be exclusively given, in its utmost extent, without destroying or essentially impairing the usefulness of the vessel in respect to some other requisite properties.

Since the introduction and extension of railway conveyance have appeared to threaten almost to supersede the use of canals, particularly in cases where *speed* of transportation was an essential object, the attention of a portion of the community has been directed to the question, whether the supposed limit to the speed of canal boats, occasioned by the accumulated resistance of the water in proportion to the increased velocity of the boat, might not be overcome. The laws of matter and motion, however, were confidently supposed to preclude the possibility of success, to any degreee which should approach to the velocity already attained on railways, (unless perhaps at an expense of motive power greater than would be justifiable in practice.) But experiments were instituted in Gt. Britain, which soon determined that a speed of at least 15 miles per hour was attainable by a canal boat, with the power of a single horse. (I refer here to experiments on the Ardrossan, and on the Forth and Clyde canals, in 1830.) Later experiments may have produced still higher results, but I do not recollect to have seen any accounts of such. Mr. Burden's experiment, however, seems, so far as we can judge at present, to establish the fact that, by the power of steam, any desirable degree of velocity may be obtained on *smooth* water as easily as on land. The

disparity, therefore, between railway and canal transportations, so far as *velocity* is concerned, appears by this to be immensely diminished, if not perhaps annihilated; and modern science will glory over ignorant antiquity, in the discovery that the resisting power of water is no longer an insuperable impediment to the swiftness of conveyance over its surface.

But let us pause. Making certain degrees of allowance for the facility rendered by the more or less gradual and smooth outline of the curves forming the stem and stern of the boat, the power necessary to propel a vessel through the water is not so much proportioned to the *absolute weight* of the boat, or the quantity of water it displaces, as to the superficial measure of the greatest transverse section of that part of the boat which is immersed in the water. This principle has long been applied to practice in the construction of boats used to ascend our rapid rivers with heavy loads. These have been made as narrow as they would bear without upsetting, or becoming too unsteady for safety; and as long as they would bear without breaking, when they happened to lie aground; perfectly straight on the floor, with as long a rake, fore and aft, as was consistent with convenient management. They were so constructed from the observation of facts, obvious to the eye of the practical boatman, without reference to recondite principles of physical science, because they knew no more of those principles than their effect on the subject matter of their daily occupations. Yet they gained one of the points long sought by science. They transported their loads, ascending against the smooth rapid currents of our rivers, with the least possible expenditure of muscular power, which was the only power then employed; and this point was all they sought. But there were other points not attained in this simple construction. The long flat bottom, and strait "wall sides," were well adapted to easy motion in a direct line forward, in perfectly smooth water, but to move in a curve line was not so easy; and to double a short point, or follow the sinuosities of some of the rivers and streams, without constantly chafing against the banks, would require more power to be exerted laterally, than would be requisite for the *direct* propulsion of the boat in the strongest current. To navigate, also, in *rough* water, the long low-sided boat was unfit: the short waves, not sufficiently broad and gradual to bear up the whole boat, were yet sufficiently high to break over its sides, and fill and sink it.

Mr. Burden's improvement remedies both these disadvantages. The curves of the *bottom*, as well as the sides of his boat, facilitate the steering, and place it under the control of the helm. His *tight deck*, (for so that part of his boat which lies out of the water may be termed,) prevents the filling and sinking of the boat in rough water; though, perhaps, something of its speed in a *direct* line and *smooth* water may be sacrificed by the greater transverse section of the bilge. But this is a minor consideration, compared with its other advantages. The great length, compared with its small transverse section, gives the advantage of increasing the tonnage without increasing the direct resistance to its speed; and the arched form of the whole gives it all the strength which is consistent with other indispensible properties.

But the example of the river-boats, which I have cited, is not the only instance of the successful application *in practice* of principles unknown in *theory*, (unless the practical observations of the untutored savage may be said to be scientific theory in another form.) I have, many years ago, with emotions of surprize and pleasure, watched the rapid gliding of the long, slender, curvilinear forms of the cedar canoes of the Indians navigating the waters of the Oronoke —the apparent ease with which they propelled them with their light paddles—the velocity of their direct movements, and the graceful ease of their steerage. With similar feelings I have seen and navigated the light birch bark canoe of the Indians of the Penobscot. Their speed—ease of propulsion—facility of evolutions—safety, in *skilful*, yet fragility and danger in *un*skilful, hands,—have long been a theme of admiration to those to whom familiarity has not rendered the sight indifferent. These, with those of the Oronoke, and other parts of the south, and, as far as I can judge from the descriptions I have seen, the astonishingly swift *pirogues* of the South Sea Islanders, are all actually formed, *at and below their water-line*, substantially on the principle of Mr. Burden's *parabolic spindle!* The savage fashions his rude bark in the form which the *experience* of his forefathers has taught him was best adapted to obtain the ends desired—speed, safety, and ease of evolution, so far as circumstances would admit of their combination. But one thing more was wanting: the least possible width to the boat was necessary to diminish the resistance of the water to its rapid flight; but this rendered it too liable to be upset. To remedy this, the "outrigger," and the "double-canoe" of the South Seas, appear. These perhaps may have afforded the hint for the "*twin boat*," introduced but a few years ago on the Forth and Clyde canal—and now to the latter succeeds, *on the same radical principle*, the "*twin parabolic spindle raft*" (if I may be allowed to coin the appellation) of Mr. Burden. * * *

It is yet to be ascertained whether Mr. Burden's boat will prove as valuable an improvement in navigating the ocean, as it appears to be in the mode of river and canal navigation. Its "tight deck" gives it, in some respects, the advantage over its partial prototype, the Indian canoe; but, for *some* purposes, the form of the latter may be preferred. It may, also, at present be doubted, whether the extreme length of the projecting part of the "spindle," level with the surface of the water, may not, in *ocean* navigation, expose it so much to the power of the waves as to impede its motion and endanger its safety, more than sufficient to counterbalance its other advantages. But this is only the precautionary suggestion of ignorance; and I would not, by any means, utter it to damp the ardor of inventive improvement, or

diminish the credit due to the experiment thus far. Mr. Burden will doubtless be stimulated by his present success, to study still farther improvements; and will not, I am sure, impute the observations I have made to any unfriendly spirit. They are made on the spur of the moment, under the influence of real pleasure at the annunciation I have just seen of his experiment, and a disposition to contribute my mite towards bringing to view any such facts in the history of the arts as may afford any lessons or hints useful to the cause of general improvement. The facts I have alluded to prove, at least, that one part of Mr. Burden's principle—the form of his boat below the water-line—is a sound one; that it has stood the test of long experiment. With respect to the other part—the unity of the whole to prevent the dangers, in rough water, of almost constant submersion—perhaps the "*kajak*" of the Greenlander may afford an analogy of *some* importance. So that, on the whole, should Mr. Burden's first experiment fail, or come short of *complete* success, he will have the support of long-tried facts to sustain him in asserting the soundness of the *principles*; and need only to direct his attention to such improvements as may be necessary in the *details*, to make his invention complete in *all* respects. Every American—indeed, every friend to the success of rightly-directed enterprize and the improvement of the condition of man—must cordially wish him success. G.

Animal Mechanics, or Proofs of Design in the Animal Frame. [From the Library of Useful Knowledge.]

INTRODUCTION.

To prepare us for perceiving design in the various internal structures of an animal body, we must first of all know that perfect security against accidents is not consistent with the scheme of nature. A liability to pain and injury only proves how entirely the human body is formed with reference to the mind; since, without the continued call to exertion, which danger and the uncertainty of life infer, the developement of our faculties would be imperfect, and the mind would remain, as it were, uneducated.

The contrivances (as we should say of things of art,) for protecting the vital organs, are not absolute securities against accidents; but they afford protection in that exact measure or degree calculated to resist the shocks and pressure to which we are exposed in the common circumstances of life. A man can walk, run, leap, and swim, because the texture of his frame, the strength and power of his limbs, and the specific gravity of his body, are in relation with all around him. But were the atmosphere lighter, the earth larger, or its attraction more—were he, in short, an inhabitant of another planet,—there would be no correspondence between the strength, gravity, and muscular power of his body, and the elements around him, and the balance in the chances of life would be destroyed.

Without such considerations the reader would fall into the mistake that weakness and liability to fracture imply imperfection in the frame of the body, whereas a deeper contemplation of the subject will convince him of the incomparable perfection both of the plan and of the execution. The body is intended to be subject to derangement and accident, and to become in the course of life more and more fragile, until, by some failure in the frame-work or vital actions, life terminates.

And this leads us to reflect on the best means of informing ourselves of the intention or design shown in this fabric. Can there be any better mode of raising our admiration than by comparing it with things of human invention? It must be allowed, that we shall not find a perfect analogy. If we compare it with the forms of architecture—the house or the bridge are not built for motion, but for solidity and firmness, on the principle of gravitation. The ship rests in equilibrium prepared for passive motion, and the contrivances of the ship-builders are for resisting an external force: whilst in the animal body we perceive securities against the gravitation of the parts, provisions to withstand shocks and injuries from without, at the same time that the frame-work is also calculated to sustain an internal impulse from the muscular force which moves the bones as levers, or, like a hydraulic engine, propels the fluids through the body.

As in things artificially contrived, lightness and motion are balanced against solidity and weight, it is the same in the animal body.

A house is built on a foundation immoveable, and the slightest shift of the ground, followed by the ruin of the house, brings no discredit on the builder; for he proceeds on the certainty of strength from gravitation on a fixed foundation. But a ship is built with reference to motion, to receive an impulse from the wind, and to move through the water. In comparison with the fabric founded on the fixed and solid ground, it becomes subjected to new influences, and in proportion as it is fitted to move rapidly in a light breeze, it is exposed to founder in the storm. A log of wood, or a Dutch dogger, almost as solid as a log, is comparatively safe in the trough of the sea during a storm—when a bark, slightly built and fitted for lighter breezes, would be shaken to pieces: that is to say, the masts and rigging of a ship (the provisions for its motion) may become the

source of weakness, and, perhaps, of destruction; and safety is thus voluntarily sacrificed in part, to obtain another property of motion.

So in the animal body: sometimes we see the safety of parts provided for by strength calculated for inert resistance; but when made for motion, when light and easily influenced, they become proportionally weak and exposed, unless some other principle be admitted, and a different kind of security substituted for that of weight and solidity: still a certain insecurity arises from this delicacy of structure.

We shall afterwards have occasion to show that there is always a balance between the power of exertion and the capability of resistance in the living body. A horse or a deer receives a shock in alighting from a leap; but still the inert power of resisting that shock bears a relation to the muscular power with which they spring. And so it is in a man: the elasticity of his limbs is always accommodated to his activity; but it is obvious, that in a fall, the shock, which the lower extremities are calculated to resist, may come on the upper extremity, which, from being adapted for extensive and rapid motion, is incapable of sustaining the impulse, and the bones are broken or displaced.

The analogy between the structure of the human body and the works of human contrivance, which we have to bring in illustration of the designs of nature, is, therefore, not perfect; since sometimes the material is different, sometimes the end to be attained is not precisely the same; and, above all, in the animal body a double object is often secured by the structure or frame-work, which cannot be accomplished by mere human ingenuity, and of which, therefore, we can offer no illustration strictly correct.

However ingenious our contrivances may be, they are not only limited, but they present a sameness which becomes tiresome. Nature, on the contrary, gives us the same objects of interest, or images of beauty, with such variety, that they lose nothing of their influence and their attraction by repetition.

If the reader has an imperfect notion of design and providence, from a too careless survey of external nature, and the consequent languor of his reflections, we hope that the mere novelty of the instances we are about to place before him may carry conviction to his mind; for we are to draw from nature still, but in a field which has been left strangely neglected, though the nearest to us of all, and of all the most fruitful.

Men proceed in a slow course of advancement in architectural, or mechanical, or optical sciences; and when an improvement is made, it is found that there are all along examples of it in the animal body, which ought to have been marked before, and which might have suggested to us the improvement. It is surprizing that this view of the subject has seldom, if ever, been taken seriously, and never pursued. Is the human body formed by an all-perfect Architect, or is it not? And, if the question be answered in the affirmative, does it not approach to something like infatuation, that possessing such perfect models as we have in the anatomy of the body, we yet have been so prone to neglect them?

We undertake to prove that the foundation of the Eddystone lighthouse, the perfection of human architecture and ingenuity, is not formed on principles so correct as those which have directed the arrangement of the bones of the foot; that the most perfect pillar or kingpost is not adjusted with the accuracy of the hollow bones which support our weight; that the insertion of a ship's mast into the hull is a clumsy contrivance, compared with the connections of the human spine and pelvis; and that the tendons are composed in a manner superior to the last patent cables of Huddart, or the yet more recently improved chain-cables of Bloxam.

Let us assume that the head is the noblest part; and let us examine the carpentry and architectural contrivances exhibited there.

But before we give ourselves up to the interest of this subject, it will gratify us to express our conviction, that the perfection of the plan of animal bodies, the demonstration of contrivance and adaptation, but more than these, the proof of the continual operation of the power which originally created the system, are evinced in the property of life,—in the adjustment of the various sensibilities,—in the fine order of the moving parts of the body,—in the circulation of living blood,—in the continual death of particles, and their removal from the frame,—in the permanence of the individual whilst every material particle of his frame is a thousand times* changed in the progress of his life. But this is altogether a distinct inquiry, and we are deterred from touching upon it, not more from knowing that our readers are not initiated into it,

* The old philosophers gave out that the human body was seven times changed during the natural life. Modern discoveries have shown that the hardest material of the frame is changing continually; that is, every instant of time from birth to death.

than from the depth ano very great difficulty of the subject.

CHAPTER I.

ARCHITECTURE OF THE SKULL.—It requires no disquisition to prove that the brain is the most essential organ of the animal system, and being so, we may presume that it must be especially protected. We are now to inquire how this main object is attained?

We must first understand that the brain may be hurt, not only by sharp bodies touching and entering it, but by a blow upon the head, which shall vibrate through it, without the instrument piercing the skull. Indeed, a blow upon a man's head, by a body which shall cause a vibration through the substance of the brain, may more effectually deprive him of sense and motion, than if an axe or a sword penetrated into the substance of the brain itself.

Supposing that a man's ingenuity were to be exercised in contriving a protection to the brain, he must perceive that if the case were soft, it would be too easily pierced; that if it were of a glassy nature, it would be chipped and cracked; that if it were of a substance like metal, it would ring and vibrate, and communicate the concussion to the brain.

Further thoughts might suggest, that whilst the case should be made firm, to resist a sharp point, the vibrations of that circular case might be prevented by lining it with a softer material; no bell would vibrate with such an incumbrance—the sound would be stopped like the ringing of a glass by the touch of a finger.

If a soldier's head be covered with a steel cap, the blow of a sword which does not penetrate will yet bring him to the ground by the percussion which extends to the brain; therefore, the helmet is lined with leather, and covered with hair, for, although the hair is made an ornament, it is an essential part of the protection: we may see it in the head-piece of the Roman soldier, where all useless ornament, being despised as frivolous, was avoided as cumbrous.

We now perceive why the skull consists of two plates of bone, one external, which is fibrous and tough, and one internal, dense to such a degree that the anatomist calls it *tabula vitrea* (the glassy table).

Nobody can suppose this to be accidental. It has just been stated that the brain may be injured in two ways: a stone or a hammer may break the skull, and the depressed part of the bone injure the brain; whilst, on the other hand, a mallet struck upon the head will, without penetrating, effectually deprive the brain of its functions, by causing a vibration which runs round the skull, and extends to every portion of its contents.

Were the skull, in its perfect or mature state, softer than it is, it would be like the skull of a child; were it harder than we find it is, it would be like that of an old man. In other words, as in the former it would be too easily pierced, so in the latter it would vibrate too sharply and produce concussion. The skull of an infant is a single layer of elastic bone; on the approach to manhood it separates into two tables; and in old age it again becomes consolidated. During the active years of man's life the skull is perfect: it then consists of two layers, united by a softer substance; the inner layer is brittle as glass, and calculated to resist any thing penetrating; the outer table is tough, to give consistence, and to stifle the vibration which would take place if the whole texture were uniform and like the inner table.

The alteration in the substance of the bones, and more particularly in the skull, is marvellously ordered to follow the changes in the mind of the creature, from the heedlessness of childhood to the caution of age, and even the helplessness of superannuation.

The skull is soft and yielding at birth; during childhood it is elastic, and little liable to injury from concussion; and during youth, and up to the period of maturity, the parts which come in contact with the ground are thicker, whilst the shock is dispersed towards the sutures (the seams or joinings of the pieces,) which are still loose. But when, with advancing years, something tells us to give up feats of activity, and falls are less frequent, the bones lose that nature which would render concussion harmless, and at length the timidity of age teaches man that his structure is no longer adapted to active life.

We must understand the necessity of the double layer of the skull, in order to comprehend another very curious contrivance. The sutures are the lines of union of the several bones which form the *cranium**, and surround and protect the brain. These lines of union are called *sutures*, (from the Latin word for *sewing*,) because they resemble seams. If a workman were to inspect the joining of two of the bones of the cranium, he would admire the minute dovetailing by which one portion of the bone is inserted

* *Cranium*, from a Greek word, signifying a helmet. The cranium is the division of the skull appropriated to the protection of the brain; it consists of six bones—the *frontal* (or forehead); two *parietal* (walls or side bones); the *occipital* (back of the head); and two *temporal* (or temple) bones.

into, and surrounded by, the other, whilst that other pushes its processes or juttings out between those of the first in the same manner, and the fibres of the two bones are thus interlaced, as you might interlace your fingers. But when you look to the internal surface, you see nothing of this kind; the bones are here laid simply in contact, and this line by anatomists is called *harmonia*, or harmony. Architects use the same term to imply the joining by masonry. Whilst the anatomists are thus curious in names, it is provoking to find them negligent of things more interesting. Having overlooked the reason of the difference in the tables of bones, they are consequently blind to the purpose of this difference of the outward and inward part of a suture.

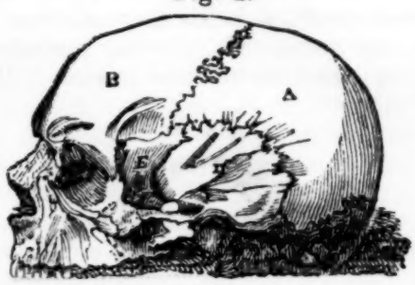
Suppose a carpenter employed upon his own material, he would join a box with minute and regular indentations by dovetailing, because he knows that the material on which he works, from its softness and toughness, admits of such adjustment of its edges. The processes of the bone shoot into the opposite cavity with an exact resemblance to the foxtail wedge of the carpenter—a kind of tenon and mortice when the pieces are small.

But if a workman in glass or marble were to inclose some precious thing, he would smooth the surfaces and unite them by cement, because, even if he could succeed in indenting the line of union, he knows that his material would chip off on the slightest vibration. The edges of the marble cylinders which form a column are, for the same reason, not permitted to come in contact; thin plates of lead are interposed to prevent the edges, technically termed *arrises*, from chipping off or splitting.

Now apply this principle to the skull. The outer softer tough table, which is like wood, is indented and dove tailed; the inner glassy table has its edges simply laid in contact. It is mortifying to see a course of bad reasoning obscure this beautiful subject. They say that the bone growing from its centre, and diverging, shoots its fibres betwixt those which come in an opposite direction; thus making one of the most curious provisions of nature a thing of accident. Is it not enough to ask such reasoners, why there is not a suture on the inside as well as on the out?

The junction of the bones of the head generally being thus exact, and like the most finished piece of cabinet work, let us next inquire, whether there be design or contrivance shown in the manner in which each bone is placed upon another.

Fig. 1.



A, the parietal bone; B, the frontal bone; C, the occipital bone; D, the temporal bone; E, the sphenoid bone.

When we look upon the side of the skull thus, the temporal suture betwixt the bones A and D is formed in a peculiar manner; the lower or temporal bone laps over the superior or parietal bone. This, too, has been misunderstood: that is to say, the plan of the building of the bones of the head has not been considered, and this joining, called the squamous* suture, which is a species of scarfing, has been supposed a mere consequence of the pressure of the muscle which moves the jaw.

Dr. Monro says, "the manner how I imagine this sort of suture is formed at these places, is that, by the action of the strong temporal muscles on one side, and by the pressure of the brain on the other, the bones are made so thin that they have not large enough surfaces opposed to each other to stop the extension of their fibres in length, and thus to cause the common serrated appearance of sutures; but the narrow edge of the one bone slides over the other."

The very name of the bones might suggest a better explanation. The *ossa parietalia*† are the two large bones in a regular square, serving as walls to the interior, or room of the head, where the brain is lodged. (See A, in the foregoing figure.)

Did the reader ever notice how the walls of a house are assisted when thin and overburdened with a roof?

The *wall plate* is a portion of timber built into the wall, to which a transverse or tie-beam is attached by carpentry. This *cogging*, as it is termed, keeps the wall in the perpendicular, and prevents any lateral pressure of the roof.‡ We sometimes see a more clumsy contrivance, a clasp, or a round plate of iron, upon the side of a wall; this has a screw going into the ends of a cross-

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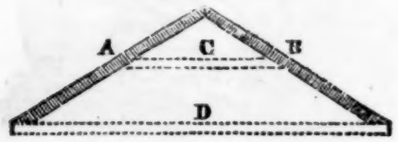
* From *squama*, the Latin for a *scale*, the thin edges lying over each other like the scales of a fish.

† From the Latin word *paries*, a wall.

‡ In the second Treatise on Heat, the reader will find an account of the manner in which the expansion of iron by heat, and its subsequent contraction on cooling, is used in order to cog great buildings.

beam, and by embracing a large portion of the brick-work, it holds the wall from shifting at this point. Or take the instance of a roof supported on inclined rafters A B:

Fig. 2.

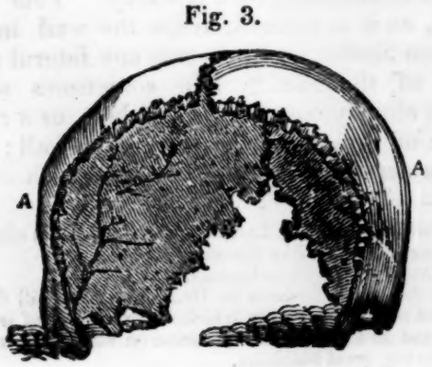


Were they thus, without further security, placed upon the walls, the weight would tend to spur or press out the walls, which must be strong and heavy, to support the roof; therefore the skeleton of the roof is made into a *truss*, (for so the whole joined carpentry is called.) The upper cross-beam, marked by the dotted lines C, is a collar-beam, connecting the rafters of the roof, and stiffening them, and making the weight bear perpendicularly upon the walls. When the transverse beam joins the extremities of the rafters, as indicated by the lower outline, D, it is called a *tie-beam*, and is more powerful still in preventing the rafters from pushing out the walls.

Now, when a man bears a burden upon his head, the pressure, or horizontal push, comes upon the lower part of the *parietal bones*, and if they had not a tie-beam, they would in fact be spurred out, and the bones of the head be crushed down. But the temporal bone, D, and still more, the sphenoid bone, E, by running across the base of the skull, and having their edges lapping over the lower part of the great walls, or the parietal bones, lock in the walls as if they had iron plates, and answer the purpose of the tie-beam in the roof, or the iron plate in the walls. But the connection is at the same time so secure, that these bones act equally as a *straining* piece, that is, as a piece of timber, preventing the tendency of the sides *of the skull* to each other.

It may be said, that the skull is not so much like the wall of a house as like the arch of a bridge: let us then consider it in this light.

Fig. 3.



We have here the two parietal bones, separated and resting against each other, so as to form an arch. In the centering, which is the wooden frame for supporting a stone arch while building, there are some principles that are applicable to the head.

We see that the arch formed by the two parietal bones is not a perfect semi-circle; there is a projection at the centre of each bone: the bone is more convex, and thicker at this part.

The cause assigned for this is, that it is the point from which ossification begins, and where it is, therefore, most perfect. But this is to admit a dangerous principle, that the forms of the bones are matter of chance; and thence we are left without a motive for study, and make no endeavor to comprehend the uses of parts. We find that all the parts which are most exposed to injury are thus strengthened: the centre of the forehead, and the projecting point of the skull behind, and the lateral centres of the parietal and frontal bones. The parts of the head which would strike upon the ground when a man falls are the strongest, and the projecting arch of the parietal bone is a protection to the weaker temporal bone.

If we compare the skull to the *centering*, where a bridge is to be built over a navigable river, and consequently where the space must be free in the middle, we find that the scientific workmen are careful, by a transverse beam, to protect the points where the principal thrust will be made in carrying up the masonry. This beam does not act as a tie-beam, but as a straining-piece, preventing the arch from being crushed in at this point.

The necessity of strengthening certain points is well exhibited in the carpentry of

Fig. 4.

roofs. In this figure it is clear that the points A A will receive the pressure of the roof, and if the joining of the puncheons* and rafters be not secure, it will sink down in the form of the dotted line. The workmen would apply braces at these angles to strengthen them.

In the arch, and at the corresponding points of the parietal bones, the object is at-

* The puncheons are the upright lateral pieces; the rafters are the timbers which lie oblique, and join the puncheons at A A.

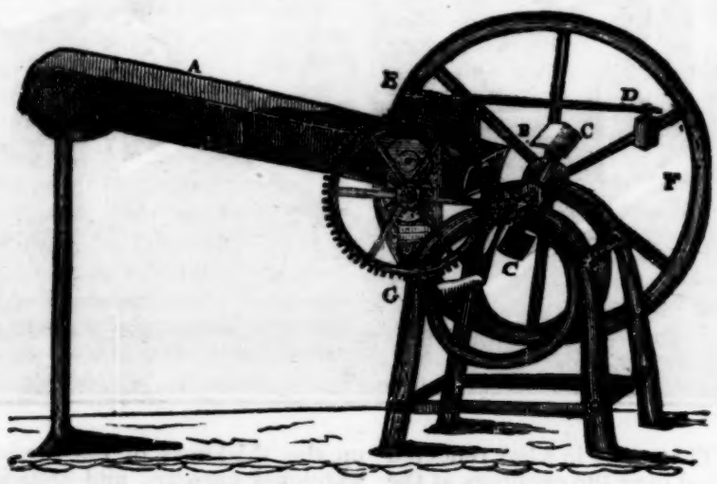
tained by strengthening these points by increase of their convexity and thickness; and where the workman would support the angles by braces, there are ridges of bone in the calvaria,* or roof of the skull.

If a stone arch fall it must give way in two places at the same time; the centre cannot sink unless that part of the arch which springs from the pier yields; and in all arches, from the imperfect Roman arch to that built upon modern principles, the aim of the architect is to give security to this point.

In the Roman bridges still entire, the arch rises high, with little inclination at the lower part; and in bridges of a more modern date, we see a mass of masonry erected on the pier, sometimes assuming the form of ornament, sometimes of a tower or gateway, but obviously intended at the same time, by the perpendicular load, to resist the horizontal pressure of the arch. If this be omitted in more modern buildings, it is supplied by a finer art, which gives security to the masonry of the pier, (to borrow the terms of anatomy,) by its internal structure.

In what is termed Gothic architecture, we see a flying buttress springing from the outer wall, carried over the roof of the aisle, and abutting against the wall of the upper part, or *clere-story*. From the upright part of this masonry, a pinnacle is raised, which at first appears to be a mere ornament, but which is necessary, by its perpendicular weight, to counteract the horizontal thrust of the arch.

* From the Latin *calva* or *calvaria*, *a helmet*.



Improved Straw and Hay Cutting Machine. [From the Edinburgh Quarterly Journal of Agriculture.]

The annexed cut exhibits one of these improved machines, as manufactured by Messrs. Slight and Lillie, with the framing made entirely of cast iron. A is the feeding-trough, the rollers being only partially seen. B is the nozzle or cutting-box. C C, the cutter-bearers, with the cutters attached by their bolts. D is a lever and weight, which, through the medium of the bridge E, keeps a constant pressure on the feeding-rollers, to counteract any inequality of feeding. F is the fly-wheel for equalizing the motion; and G, the handle to which the power is applied. The small pinion on the fly-wheel shaft gives motion to the spur-wheel, which is mounted on the shaft of the lower feeding-roller, and carries also the lower feeding-pinion. This last pinion works into the pinion of the upper roller, and both being furnished with very long teeth, they thereby admit of a limited range of distance between the rollers, according to the quantity of feed.

With one of these machines, a man, assisted by a boy to feed in the hay or straw, can cut at the rate of eight stones per hour; and that quantity of cut hay is found to be sufficient for sixteen horses for twenty-four hours.

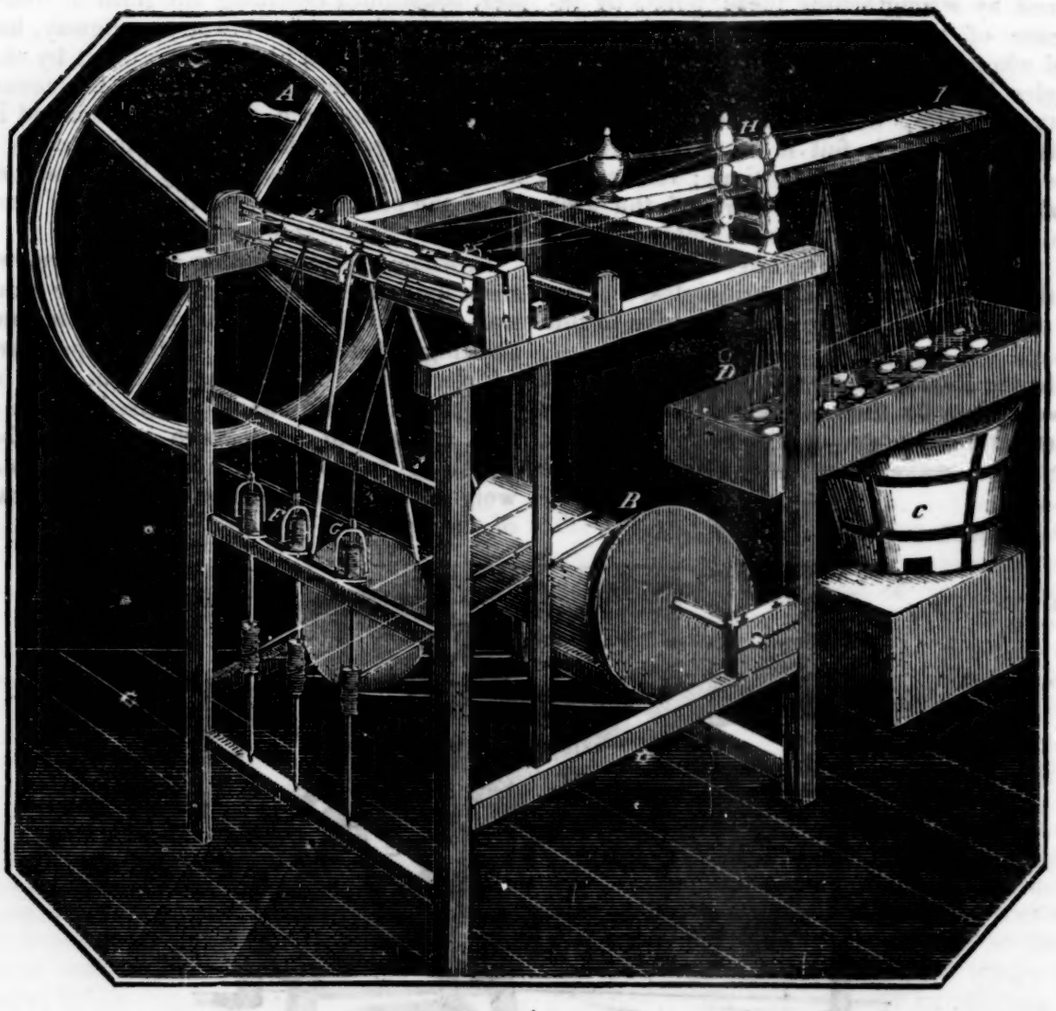
The machine, of which the above is a figure and description, combines, in an eminent degree, expedition and efficiency, with ease to the workman. We do not think it can be made of a simpler construction.

Manufacture of Silk—Reeling, Twisting from the Cocoon—Description and Drawing of Brooks' Silk Machine. [From the New-York Farmer.]

The manufacture of silk is so likely to become an important branch of national industry, that we deem it important to lay before our readers all the information that we can obtain.

On the present occasion, we shall simply state the particulars of an experiment with Mr. Adam Brooks' machine.

After considerable inquiry for cocoons in this section of the country, we were enabled to obtain a bushel that had been, two years ago, sent on to this city, from one of the Southern States, for a market. In consequence of there being no demand for them, they had been put aside as a



worthless article. They were in a box rendered tight by paper pasted over the openings at the joinings of the boards. Some of the cocoons were perforated by an insect not unlike the common moth; but generally they were in excellent order.

All the practical information we had had, was from seeing Mr. Brooks exhibit his machine in operation a few times. In connection with another person, whose opportunities of practical knowledge were no greater than our own, we took a peck of the cocoons, 485 in number, and weighing ten ounces. Without assorting them, as we should have done, we put a handful of some 20 or 40 into water about boiling hot—took a small broom and pressed them into the water—found the floss silk adhering to the broom—gathered the silk from the broom, and kept drawing the silk until a fibre ran off singly and evenly from each cocoon—lifted these running cocoons from the water with an instrument not half so convenient as a skimmer, and placed them in a winding basin partly filled with heated water—served other cocoons in the same manner until we acquired two threads of about 100 fibres or cocoons, and carried the threads through the guide wires, between the rollers, to the bobbins. Thus prepared, we began to wind by turning the wheel, keeping up the thickness of the thread by supplying additional cocoons, and collecting and attaching the ends of those that had broken. After a sufficient quantity was on the bobbins, took them and placed them in the upright posts, and carried the ends through the guides and rollers to the bobbin, for the purpose of doubling and twisting. Replacing the bobbins with two more, we then, by turning the wheel, wound, doubled, and twisted the silk at one operation. Thus continuing, we obtained from the peck 1¼ ounces of fine sewing silk, which, when deprived of the gum, by being several times boiled in soap suds, weighed one ounce. Besides this, there were 4¼ ounces of floss silk obtained from the gathering of the silk from the broom, from cocoons that would not wind, and from those that had been injured by insects, or imperfectly formed. These 4¼ ounces, after having been cleansed in soap suds, weighed 3 ounces. This floss silk is to be carded and spun for stockings and other purposes.

The sewing silk being very fine, did not, owing to the improper adjustment of the machine, give a sufficient twist; in other respects it was pronounced a fair, saleable article. When it is considered that we were entirely *green* at the business, were several times obliged, as soon as we got into operation, to omit our labors for

another day, and were not in possession of the conveniences for producing a good article, our readers will perceive that the manufacture of silk for common domestic purposes is not more difficult than to spin flax or wool, which was formerly done by the females of almost every farmer's family in the country.

Our lowest estimate of the value of the bushel when made into sewing and floss silk, is $4,50. Our information, however, relative to its price, is derived from books and personal inquiries, and is extremely varied, and often contradictory. One thing is very certain, that if $2 50 to $3 50 per bushel for the cocoons is a remunerating price to the farmer, the manufacture of them into silk in his own family must be very profitable.

The machine, the drawing of which accompanies this article, is the invention of Mr. Adam Brooks, of Scituate, Mass. It is admirably adapted for families, when sewing silk is intended to be made. The one we used is a beautiful machine, made of mahogany, in a substantial and workmanlike manner. It cost $28. Those of hard but less costly wood, and thoroughly made, are $25. With an additional bobbin, $30 and $26.

Machines made by the inventor may be had of the agents, H. Huxley and Co. 81 Barclay street

REFERENCES.—A, the handle of the crank, giving motion to the machine. There is a band around the large wheel, passing around a small wheel attached to the axis of the cylinder or drum. B, the drum or cylinder, around which the bands giving motion to the spindles pass. C, the furnace for heating to blood heat the water in the pan D, containing the cocoons. E, the rollers regulating the supply of thread given to the spindles. F, the two spindles for twisting the single threads. G, the spindle for the double twisting or sewing silk. H, the two upright pillars supporting the bobbins containing the single thread to be double twisted. J, a projecting slat, containing the leading wires to receive the threads from the cocoons in the pan D.

MANUAL LABOR SCHOOL.—The first self-supporting school in the United States was opened in May of 1813, in Derby, at the head of navigation on the Housatonic river, in Connecticut. It continued eight years, during which time about twenty lads paid all their expenses for board, clothes, tuition, and books. At the time this school was opened, public sentiment was almost unanimously against it. The common remark was, that "it was good in theory, but could not be put in practice."

STEAMBOAT NEW-ENGLAND.—We are induced to insert the annexed testimony of the witnesses examined respecting the bursting of the boilers of the New-England, notwithstanding its length, on account of the importance of the general subject to which it relates, the melancholy interest connected with the case immediately under consideration, and the high scientific reputation of the gentlemen composing the Board of Examiners. Public opinion had assigned a *deficiency of water* as the cause of the explosion; but the Committee, after the most careful investigation, are unanimous in the belief that it was "the pressure of steam produced *in the ordinary way*, but accumulated to a degree of tension which the boilors were unable to sustain."

Alexander Marshall, Engineer—Was engigineer of the steamboat New-England, on the 8th October last. Left New-York a few minutes after 4 P. M., on that day, with a light pressure of steam. The engine having been started cold, the steam did not increase till we had proceeded as far as Hurlgate.

The average pressure used on the passage was from 10 to 12 inches. The steam rose after starting from 8 to 14 or 16 inches. At 7 P. M., left the engine in charge of Mr. Younger, the assistant engineer, and retired to rest with a view of taking his watch at 10 P. M. Was called by Mr. Younger at 10 o'clock. There was a heavy sea in the sound, and, in consequence of orders which Capt. Waterman had given, the steam was reduced to 8 or 9 inches. Was obliged to stop before arriving in the river by order of the pilot, in order to adjust the wheelrope. Arrived in the river about 1 o'clock A. M. Missed the wharf at Saybrook, and after a second attempt to gain the wharf, some difficulty occurred with the lifting valves, in consequence of the binders by which they are confined being screwed too tight, which made it necessary to anchor. After loosening the valve rods, the boat got under way, and landed at Saybrook. Landed also at Lyme. Just before landing at Essex, went into fire-room and examined the gauge-cocks (water-cocks,) and found the water good in the boilers. This was three or four minutes previous to the explosion. The boat was stopped about two minutes at Essex to land a passenger, with the small boat. Took hold of the pulley of the safety valve for the purpose of raising it, and at this moment the explosion took place. Does not know whether he had lifted the valve or not.

Being further examined, he says, that the steam-gauge did not exceed 14 inches while in the sound nor 10 inches after entering the river. This statement is not founded on actual measurement. There was no scale of inches marked to either of the steam-gauges. Refers only to the height of his own gauge in the engine-room. Is aware that the steam-gauges in the two fire-rooms ranged considerably higher. Ascribes the difference to the greater expansion of the mercury in the fire-rooms, from the proximity to the fire. Had a greater pressure of steam immediately previous to the explosion than was proper to use in the river, where the boat does not steer well under a strong power, and this was the reason why witness attempted to raise the safety valve.

Witness further says, that the New-England commenced her first trip on the 30th August last, under the charge of witness as engineer, he having been employed to set up the engine. The charge of the engine was afterwards given to Mr. Potter, the engineer of the company who owned the boat.

Witness again took charge of the engine on the trip previous to that on which the accident occurred, in consequence of the illness of Mr. Potter. Witness was employed as engineer of a steamboat at the South, 12 years ago, which boat was run by him during the season of navigation. Says that his management on the night of the accident was not at any time influenced by a desire to shorten the passage. Heard no inquiry made by any of the passengers about racing. The only fuel used by him in the New-England was pine wood. Witness has been 20 years engaged in his present business. Has served a regular apprenticeship in the manufacture of engines. Has been employed in New-York by Mr. M'Queen, Mr. Allaire, Mr. Sabbatton, and the West-Point Foundry Association.

The safety valve of the New-England was loaded 18 pounds in the square inch, and its position on the steam pipe is 20 feet, or more, from the boilers. Besides two regular weights on the safety valve, there were two extra weights, a 50, and a 28. The valve will blow off at 8 pounds to the square inch, with the two regular weights. This is owing to the lever of the safety valve having been shortened about 2 feet, to bring it within the walls of the room by which it is enclosed. The diameter of the safety valve is 10½ inches. The diameter of the steam pipes which lead from the boiler is about 10 inches.

Robert Younger, Assistant Engineer.—Witness started from New-York at a few minutes past 4 o'clock P. M., as assistant to Marshall. At 7 P. M., Marshall left the engine in charge of witness. About half past 8, Capt. Waterman came to the engine-room and asked if the engine did not labor too much in the sea. Also inquired the height of the steam-gauge; was answered 10 inches. Capt. Waterman requested him not to carry any more. Witness then blew off steam, and went to the fire-room and gave directions for less fire. Run with steam from 8 to 10 inches, till Mr. Marshall came on deck at 10 o'clock. Witness examined the water in the boilers frequently on the passage. Did not see the height of the steam-gauge for the last 10 or 15 minutes previous to the explosion, because his view of the gauge while standing at his post in the engine-room was obstructed by an appendage to the steam-pipe. There was no difficulty occurred in the management of the water in the boilers. One of the boilers foamed once while Mr. Marshall was below. This was immediately stopped by putting oil into the force pump. The steam was blown off at Saybrook while lying to for the purpose of loosening the binders of the lifting rods. This was before landing at Saybrook Point. The position of the bulk-head did not prevent the raising of the safety valve. Witness saw the moveable part of the bulk-head in its proper place on the morning after the accident. Is certain of this from his own personal examination. Has never witnessed an accident of this kind before. Has been 12 years engaged in the business of making engines. Made his first trip as an acting engineer in the New-England when the boat was first started. Assisted Marshall in fitting up the engine. Thinks that there was no want of water above the flues, but is of opinion that the steam had blown the water from the legs of the boilers.

William Vail, Pilot.—Says that the New-England left New-York at 12 minutes past 4 P. M. in company with the steamboat General Jackson. The steamboat Boston left the wharf soon after the New-England. The Boston gained upon the New-England till they reached Hurlgate. The New-England then got more steam on, and drew away from the Boston. Found a heavy sea in the Sound, after passing Sands' Point, and the Boston then preserved her distance. The New-England steers very badly. After passing Falkner's Island, the wheelrope got foul, and detained us a few minutes, and the boat fell into the trough of the sea. Off Killingworth, and again off Duck Island, the same detention occurred. When off Cornfield Point, (Saybrook,) witness told the engineer that the boat would not steer in the dark with such a heavy sea, and told him not to carry over seven inches, and repeated the same direction to the engineer when in the river. When crossing the bar at the mouth of Connecticut river, the boat steered very bad, and was obliged to ring the bell to shut off the steam. Missed the dock twice at Saybrook, in consequence of no person being on the dock to take a line. Backed down to near the Fort, where, owing to some difficulty with the valves, the boat could not be started ahead, and was obliged to anchor to prevent drifting on shore. Went into the engine-room and waited twenty minutes for the engineer to get ready for a start. Looked into the fire-room and asked if the water was plenty in the boilers, and was answered 'yes.' Got up the anchor and landed at Saybrook. Started again from Saybrook, and was obliged again to order the steam shut off, because it was difficult to steer the boat. Landed at Lyme, and on starting again, found that the boat jumped so with a head of steam, and steered so badly, that it was necessary to shut off the steam again, and continued shut off till we reached Essex, seven miles from Saybrook. Was detained three or four minutes in landing at Essex. When the small boat had landed, Capt. Waterman gave the word, and witness rung the bell to start the engine, and the explosion immediately followed.

The steam was not blown off at Essex. Witness thought at the time that there was too much steam on. Heard but one explosion, which was like a heavy fall or crash. Had been pilot of the New-England for 30 days, which was nearly as long as the boat had run.

The accident occurred an instant after ringing the bell to go ahead. Witness had felt apprehensions for his personal safety, on account of the pressure of steam which was carried; judged of this by the motion of the engine and the management of the boat. Saw at Saybrook the steam-gauge standing at 12 or 14 inches, and cautioned the fireman against carrying too much steam. The stop at Essex was no longer than 3 or 4 minutes.

The greatest distance gained of the Boston was about two miles and a half, which was near the head of the Sound. The Boston was nearly abreast when we entered the river. Witness is unable to make up his mind as to the cause of the accident, but thinks that the rent commenced in the legs of the boiler near the after end.

Giles Farnham, Fireman.—This witness was on duty at the larboard boiler. Took the first watch from New-York, and went below at 8 o'clock. Took his second watch after 12 o'clock, just before the boat entered the river. There were but 8 or 10 inches steam on the boiler before the boat arrived at Saybrook. The steam-gauge rose to 12 or 13 inches while lying at anchor at that place. Blew off the steam to 7 inches, and pumped water by hand into the larboard boiler. Witness says the water was lower in the boiler at this time than at any other, being at the 2d cock. The other boiler needed no supply. Witness examined the water every five minutes. Started from Saybrook with water at three cocks, and kept it afterwards at four cocks till the time of the accident. Above Lyme there was more steam on than there ought to be for the river. The floating stick in the steam-gauge in the larboard furnace was within two inches of the upper or boiler deck, when the boat stopped at Essex, and witness supposes it must have reached the deck previous to the accident.

While the boat was stopped at Essex, tried the water-cocks, and found the water as high as the upper cock. The witness then went over to the starboard fire-room, and told Bell, the other fireman on duty, that "he would not have to fire up again for a week if they went on so." Had but a moderate fire at this time in the furnace. Says the extra pressure was owing to the engine being shut off so much. At the moment of the explosion witness was sitting on the rail of the fire-room gangway, at the outside of the guard, conversing with Bell, the other fireman. Witness heard a sudden cracking of the boiler, and attempted to look round to see what was the matter, which was the last he knew till he found himself in the water. Was severely scalded, but succeeded in swimming to the shore. Witness says that when there was no steam on the boiler, the top of his gauge-rod was so short as to fall three inches below the top of the muzzle of the steam-gauge, and therefore did not indicate so much pressure as the gauge of the other boiler, that is, did not indicate the whole amount of pressure by three inches.

Edwin Bell, Fireman.—Was in charge of the starboard boiler at the time of the accident. Left New-York with seven inches steam, and carried about the same pressure till through Hurlgate, after which carried 12 or 13 inches till dark.

Was then directed by Mr. Younger to keep 8 or 9 inches, which was done till 8 o'clock, when witness took his watch below. Came on duty, and took the fire again at Saybrook, at which time there were 8 or 9 inches of steam on, and the fire was run down. Capt. Waterman came and asked witness about the water, examined and found three full cocks. Witness had no occasion to supply his boiler by the hand-pump. At Lyme, the steam-gauge was at 12 or 13 inches, and on reaching Essex, the gauge-rod was within 3 or 4 inches of the upper deck.

When the boat stopped it soon rose to the deck. Witness then turned off the condensed water from the steam-gauge, which caused it to fall about two inches, but it soon rose as high as before. Tried the water-cocks, and found good solid water at three lower cocks, and steam and water at the upper cock. Went over to the larboard boiler when first we stopped at Essex, and found 3 cocks of good water, and the gauge-rod three or four inches from the deck. The gauge-rod of the starboard boiler usually stood higher than the one in the larboard fire-room.

Witness never saw the float rods of the steam-gauges so high as at this time. Has run in the boat from her first trip. Witness told Giles (Farnham,) when the latter came into his room, "that they would not have to fire up more than once more during the whole watch."

There was a light fire kept up between Lyme and Essex. Witness heard no steam blown off at Essex. The accident happened about 3 o'clock in the morning. The New-England came out from New-York before the Boston. At 8 o'clock the Boston was about two miles astern.

Isaac Seymour, Mate.—Agrees in the statements made by Mr. Vail. In the Sound, from Sands' Point to Matinecock Point, the steam stood at the pressure of about 8 inches, and Mr. Marshall was some time blowing off. Marshall said that it was made faster than he wanted it, and he should speak to the firemen. Thinks there were 10 or 12 inches on the gauge in the engine-room, at the time when the boat was anchored at Saybrook, and they commenced blowing off. Saw the water tried in the boilers at Saybrook, which showed plenty. The larboard boiler was then pumped into by hand.

Perceived no difficulty in working the boat, except at Saybrook. Was not apprehensive of any accident. Was employed in landing with the small boat at Essex. Saw Mr. Marshall visit the fire-room just before the landing at Essex. Witness was facing the dock when he first heard a cracking noise, and was in the act of turning towards the steamboat when the explosion instantly followed.

The larboard boiler, which was nearest to witness, exploded a little before the other. Could just perceive the difference.

Roswell Potter, Engineer.—Witness has run the New-England as engineer since she first commenced running, except the first and last trip, when he stayed back on account of ill health. Had no reason to expect that any thing would go wrong. Usually carries from 14 to 17 inches of steam on the boilers of the New-England. The engine is intended for carrying 16 to 18 inches. Safety valve, as loaded at the time of the accident, would begin to blow off at 18 inches. Had three steam-gauges, which would rise from 31 to 32 inches without blowing out the mercury. Steam-gauges of this length are now used in the steamboats. The gauges in the fire-rooms would stand 3½ inches higher than the engineer's gauge in the engine-room; supposes this to be owing to the loss of heat from the steam in passing through the steam-pipe. Has run with Capt. Bunker to New-Haven, with steam at 8 inches. This was several years ago. Boilers are now made stronger than those which were formerly used.

The extreme of safe pressure on the boilers of the New-England he thinks to be 22 to 24 inches. The boat would not sail faster with this pressure than with 17 inches. Has had 24 inches on the boilers; once, when the boat was on trial, and at other times since. This was occasioned by stopping the engine. Has not seen the gauge rods rise as high as the boiler deck in any case. Witness examined the steam-gauge in the engine-room after the accident, and found it in perfect order, with the mercury remaining in the gauge. Also, found mercury in one of the fire-room gauges, both of which were torn down by the explosion. The height of the gauge rod, when up to the deck in the fire-room, would be 28 inches. After turning off the condensed water from above the mercury, we get the true guage. Has not known any racing with the New-England, except with the steamboat Providence, on which occasion had bad wood, and could get a pressure of but 11½ inches. The engineer must stand constantly at the engine to attend to the orders of the pilot. Was engineer of the steamboat Oliver Ellsworth for several years, and usually carried from 12 to 14 inches of steam on the boiler of that boat. The Oliver Ellsworth has the strongest boiler. The latter is made of stouter copper than those of the New-England, is 9½ feet in diameter by 16¼ feet in length, and is stronger braced than any boiler the witness has ever seen. The engine of the New England is nearly four times the power of that of the Oliver Ellsworth. Thinks that the middle legs of the boilers were heated, and that they now appear to be annealed, and different from the outside of the boiler. The force pumps of the New England are very large, and will fill the boilers running over full from Saybrook to Essex. The New England will steer well with 8 or 10 inches steam in smooth water. The Oliver Ellsworth formerly carried from 12 to 14 inches, and now carries 16 to 18 inches. The M'Donough carries 12 to 14 inches. On being further examined, witness says that one of the boilers of the New-England was patched twice on the middle leg at the after end, and that a similar patch was put upon the same part of the other boiler. There was a crack in the flange at this point, which made it leak, but these repairs did not stop it. This was the trip previous to the accident. The safety valve would commence blowing off at 18 inches, but had carried 24 inches with the same weights, with the steam blowing through the valve. The boilers had not been proved above 24 inches. Had found the brace-bolts between the top of the furnace and the connection of the flues to the steam chimney to be leaky, owing to a straitening in the angle of the braces. Had taken them out, and put strait screw bolts in their stead. This was on the second trip which the boat made. Considers the engine to be of 120 horse power.

Adam Hall, Engineer.—Witness is chief engineer of the establishment of the West-Point Foundry Association. Made the engine and boilers of the New England. The boilers were 8 feet 4 inches wide, 8 feet high, and about 15 feet long. Each boiler had two arched flues and five circular return flues of 16 inches in diameter.

The arches were made of rolled copper, No. 3, wire gauge, the outer shell of No. 4, and the circular flues of No. 5. The boilers were placed one on each guard of the steamboat, at the distance of about 25 feet from the engine. The boilers were strongly braced with ⅞ inch bolts through the legs or flat sides, at the distance of 9 inches, and the arches were secured to the upper parts of the boiler by long bolts of ¾ inch copper, with screw fastenings. The steam-pipes were also of copper 10 or 10½ inches in diameter, and the safety valve was of the diameter of 10½ inches. The latter was calculated to blow off at a pressure of 20 inches; but the lever was afterwards shortened to about two feet, and new weights added, after the boat commenced running. There were four water cocks on each boiler, for ascertaining the height of the water.

The lowest of these cocks was three inches above the highest part of the upper flues, and each successive cock was placed three inches higher than the preceding one, the upper cock being twelve inches above the flues. Witness had proved the boilers. Thinks that the boilers should have borne fifty pounds to the square inch, if there had been no previous imperfection. The strength of copper, as compared with iron, is nearly as 3 to 5. The difference witness says is 60 per cent. in favor of iron. Copper has been preferred as a material for boilers, because it suffers less from corrosion. Copper is weakened by the action of heat at about 250 degrees. The strength of iron is increased when exposed to heat up to a certain point of temperature. A copper boiler will bear a greater pressure when cold than when

heated. An iron boiler, if not heated beyond 450, will bear a greater pressure than when cold. Has tried experiments with Mr. Stevens on a flat iron boiler, braced at distances of 8 inches, with ¾ inch brace bolts, at distances of 6 inches with ⅝ inch bolts, and at 5 inches with ½ inch bolts. One of the ¾ bolts broke at 756 pounds to the square inch; three of the ⅝ bolts gave way at 256 pounds to the inch, and ½ inch braces stood this pressure without injury. The power was applied by a water press, the safety valve being carefully loaded with an addition of 10 pounds at each trial. Witness thinks, from the appearance of the metal, that the rent of the boilers must have commenced in the arches near their connection with the after end. Knows Alexander Marshall, and would have no hesitation in trusting him with the care of an engine in any case. Witness employed him to take charge of a high pressure engine last winter.

Henry Waterman, Jr., Captain of the New-England.—Left New-York without working the engine warm, and run the steam down to 4 or 5 inches. The Boston left soon after us, and came up strong till we got through the gate. Then got on 10 or 12 inches of steam and drew away from the Boston. Might be 1½ or 2 miles ahead at 7½ to 8 o'clock. At this time felt a little alarmed for the laboring of the engine in the heavy sea with 12 or 15 inches. Usually works 14 or 18 inches when in full speed. Was often in the fire-room, till half past 10, when he retired. Below Falkner's Island, the wheelrope got foul, which brought him on deck, the boat boing in the trough of the sea. Crossed the bar, and got into the river at 1 o'clock, it being low water. Made two attempts to land at Saybrook, and failed, owing to there being no one to fasten a line on shore. Anchored in consequence of a difficulty in moving the valve rods, and blew off the steam. Observed the fireman pumping up one of the boilers, and ordered others to assist him. When the engineer was ready, got under way immediately, and went to the wharf. Heard no complaint of the boat behaving worse than common. Saw nothing unusual or alarming. Carried less steam in the sound than usual, on account of the heavy sea. Should have carried from 12 to 18 inches had the water been smooth. Had a favorable passage excepting the heavy sea. Did not notice the state of the steam after leaving Saybrook. Had no apprehension, or fears of any kind, at the time, and had heard none expressed by the passengers, or other persons on board. Had full confidence in the perfection and strength of the boilers and machinery. This confidence was derived from the experience we had already had. Witness has been five years in the steamboat business, and has had charge of a boat for the last 3 years. Was making no unusual exertions to reach Hartford early, and felt no inducement to such a course.

Has accidentally fallen in company with other steamboats since he has run the New-England, and had not been able to keep as much steam while so in company as was desirable, the boilers being too small for the engine, and could not, on an average, in these cases, keep more than 13 inches. Six persons were blown overboard by the explosion, of whom two were drowned. Witness is not able to form an opinion as to the immediate cause of the accident.

Mr. Samuel M. Hayden.—The witness lives at Essex, about 25 rods from the spot were the disaster occurred. Heard the steam when the New-England arrived at Essex, the noise of which continued while the boat was landing. Witness doubts if it was three minutes from the time he first heard the steam, till the explosion took place.

His first knowledge of the arrival of the steamboat was from hearing the steam. There were two distinct explosions, following very closely, and "lapping on to each other." The last explosion appeared to be the sharpest. Fifteen persons have died, including those whose bodies were found in the river.

Such is the evidence w ch was submitted to our consideration. It was also testified by one of the firemen, that the *damper*, by means of which the fire is held in check, was not closed during the stop at Essex, a fact which has not been recorded in its proper place. We consider it a remarkable fact, as well as an important circumstance in respect to the success of our investigation, that we have been able to obtain the testimony of the engineers and firemen who were on duty at the time of the explosion, all of whom were providentially saved. This has relieved the case from much of that obscurity which has rested on other disasters of this kind, where those immediately in charge of the boilers and engine have been the principal sufferers.

We annex sketches of the longitudinal and cross sections of the boilers of the New-England, reduced from the original drafts from which the boilers were constructed, which will serve to illustrate the foregoing descriptions.

The various theories and conjectures which have been put forward to account for this disaster may be comprized under the three following heads:

1. The production of some *gas*, (probably hydrogen,) suddenly evolved in great quantity

2. A supposed injurious *heating of the water legs*, (*d d d*, Fig. 2,) and lower parts of the boiler, in consequence of water being driven by the steam into the upper part of the boiler, and perhaps causing a rapid production of steam on its return to the heated metal.

3. A *deficiency*, at the time of the accident, *in the quantity of water* which it is necessary to carry in the boilers, owing to the carelessness of those in attendance, or to their being deceived in the examination of the water-cocks. It has been supposed that the metal of the boilers may thus have been weakened by heat, or that the sudden suffusion of water on the metal thus heated, occasioned by the sudden discharge of steam at the safety valve, may have generated steam in such quantity, and in

a manner so instantaneous, as to destroy the boiler.

4. *Stress of steam*, accumulated beyond what the boilers were able to sustain.

1. *It is suppposed by some that the explosion was produced by gas.*

2. *Others ascribe the explosion in question, to an over heating of the water legs of the boiler.*

3. *By others, the explosion is ascribed to deficiency of water.*

After some lengthy objections to these suppositions, which we have not room for, they state—

"We are constrained to adopt the remaining conclusion, and give it as the unanimous opinion of the board of examiners,—*That the explosion of the steamboat New England was caused by the pressure of steam, produced in the ordinary way, but accumulated to a degree of tension which the boilers were unable to sustain.*"

Fig. 1—Longitudinal Section.

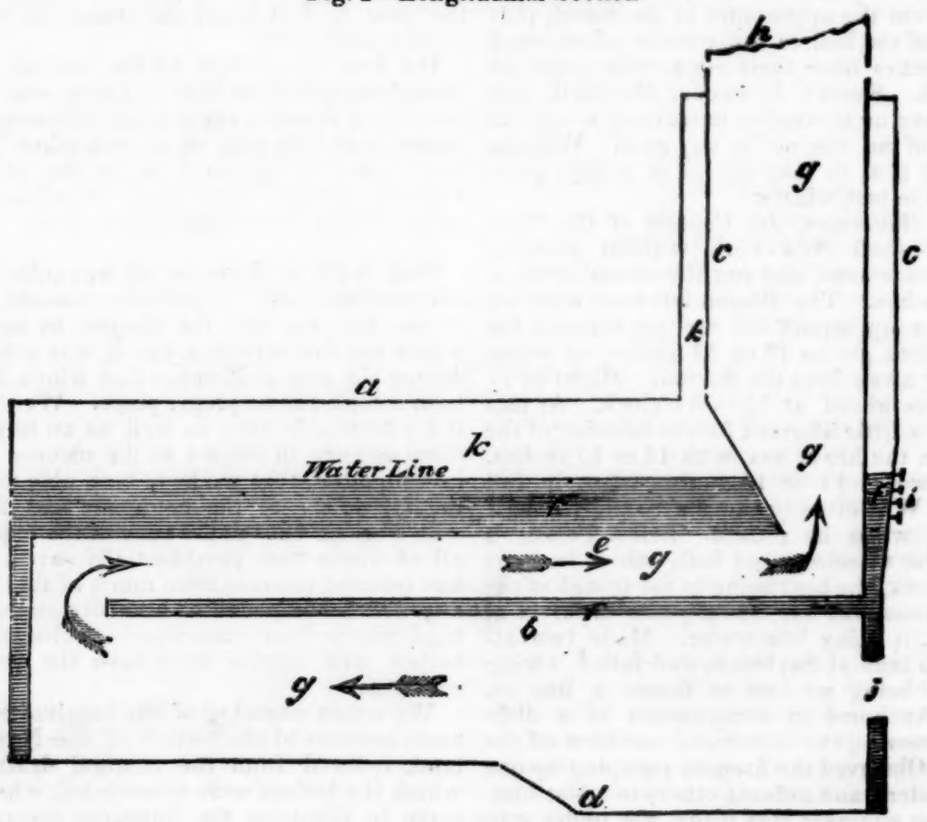
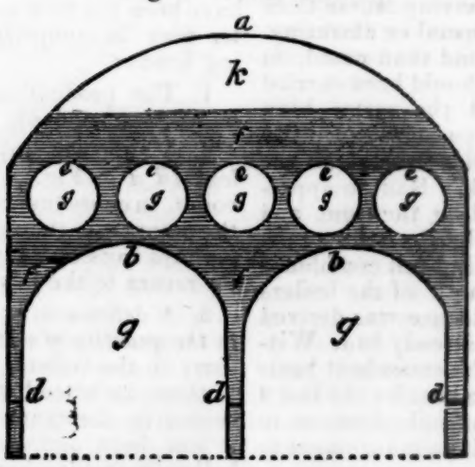


Fig. 2—Cross Section.



REFERENCES.—*a*, the outer shell of the boiler; *b b*, the arches or tops of the main or furnace flues; *c c*, the steam chimney; *d d d*, the water-legs; *e e e e e e*, the upper or return flues; *f f f*, the water in the boilers; *g g g g g*, the passage for the fire through the flues to the chimney; *h*, the iron chimney-pipe, cut off above its junction with the steam chimney; *j*, the furnace door; *k k*, the chamber; *i*, the water-cocks.

CENTRE OF GRAVITY OF A SHIP.—A discovery, which is likely to be attended with important results to the navy, has recently been made by Commander John Pearce, R. N., of Plymouth. This officer, from various circumstances, was led to doubt that the *centre of gravity of a ship* was the *axis of rotation*, as hitherto imagined, and that this was the cause of so many errors occurring in masting. He accordingly proceeded to ascertain the truth of his doubts, by experiments on different models, which he has continued for upwards of twelve months, and the result, we understand, cannot fail to render the science of ship-building more comprehensive and demonstrative, as well as lead to the correction of other errors in the theory equally worthy of consideration! The axis of rotation has been fixed, by Capt. Pearce's experiment, at some distance above the gravity of the ship, and in the point which is known by the name of the lacentre; and we understand he considers the complexity of the theory, and not having considered the subject in a sufficiently practical shape, to have led authors into the error of confounding the centre of gravity of the ship with the axis of rotation; and that this has led to the error of supposing the lateral effort of the water, or resistance to leeway, to produce effects contrary to truth, and from which proceeds the present imperfect system of masting. In fact, the discovery of the true axis of rotation will be a complete key to the improvement of naval architecture, as *all the forces*, which are so constantly and variously acting, are estimated by the distances from the axis of rotation to the points where they are applied.—[London paper.]

THE RAINBOW.—The following reflections on this phenomenon are extracted from a work of considerable talent, Mr. Burke's "Beauties, Harmonies, and Sublimities of Nature." We have been favored with the author's corrections of the passage, as it is intended to appear in a third edition of his book, which is now preparing for the press.—[Penny Mag.]

The poets feigned the rainbow to be the residence of certain aerial creatures, whose delight it is to wanton in the clouds. Milton, in his exquisite pastoral drama, thus alludes to this Platonic idea:—

> I took it for a fairy vision
> Of some gay creature in the element,
> That in the colors of the rainbow live,
> And play i' th' plighted clouds.

The rainbow, which, not improbably, first suggested the idea of arches, though beautiful in all countries, is more particularly so in mountainous ones; for, independent of their frequency, it is impossible to conceive any arch more grand (if we except the double ring of Saturn) than when its extreme points rest upon the opposite sides of a wide valley, or on the peaked summits of precipitate mountains.

One of the glories which are said to surround the throne of heaven, is a rainbow like an emerald. In the apocalypse it is described as encircling the head of an angel; in Ezekiel, four cherubim are compared to a cloud, arched with it; and nothing, out of the Hebrew scriptures, can exceed the beauty of that passage in Milton, where he describes its creation and its first appearance.

There is a picture, representing this emblem of mercy, so admirably painted, in the castle of Ambras, in the circle of Austria, that the Grand Duke of Tuscany offered a hundred thousand crowns for it. Rubens frequently gave animation to pictures, which had little beside to interest the eye of the spectator, by painting this phenomenon: one of Guido's best pieces represents the Virgin and Infant sitting on a rainbow: and round the niche in which stood a statue of the Virgin in the chapel of Loretto, were imbedded precious stones of various lustres, forming a rainbow of various colors.

The rainbows of Greenland are frequently of a pale white, fringed with a brownish yellow; arising from the rays of the sun being reflected from a frozen cloud. In Iceland it is called the Bridge of the Gods; and the Scandinavians gave it for a guardian a being called Heindaller. They supposed it to connect heaven with earth. Ulloa and Bouguer describe circular rainbows, which are frequently seen on the mountains, rising above Quito, in the kingdom of Peru; while Edward asserts, that a rainbow was seen near London, caused by the exhalations of that city, after the sun had set more than twenty minutes. A naval friend, too, informs me, that as he was one day watching the sun's effect upon the exhalations, near Juan Fernandez, he saw upwards of five and twenty *iris marinæ* animate the sea at the same time. In these marine-bows the concave sides were turned upwards; the drops of water rising from below, and not falling from above, as in the instances of aerial arches. They are sometimes formed, also, by waves dashing against the rocks: as may frequently be seen on the coast of Carnarvon, Marioneth, Pembroke, Cardigan, and Carmarthen.

In some rainbows may be discovered three arches within the purple of the common bow: 1. yellowish green, darker green, purple; 2 green, purple; 3. green, purple.

Rainbows, too, are sometimes seen when the hoar-frost is descending; and Captain Parry, in his attempts to reach the north pole by boats and sledges, saw a fog-bow, and no less than five arches formed within the main one, all beautifully colored.

Aristotle states that he was the first who ever saw a lunar rainbow: he saw only two in fifty years. He assuredly means he was the first who ever described one; since lunar rainbows must have been observed in all ages. That it was unknown to St. Ambrose, however, is evident, from his belief that the bow, which God promised Noah he would place in the firmament after the deluge, "as a witness that he would never drown the world again," was not to be understood of the rainbow, "which can never appear in the night; but some visible virtue of the Deity." Notwithstanding this assertion of St. Ambrose, I have had the good fortune to see several; two of which were, perhaps, as fine as were ever witnessed in any country. The first formed an arch over the vale of Usk. The moon hung over the blorenge; a dark cloud suspended over Myarth; the river murmured over beds of stones; and a bow, illumined by the moon, stretched from one side of the vale to the other.

The second I saw from the castle overlooking the bay of Carmarthen, forming a regular semi-circle over the Towy. It was in a moment of vicissitude; and fancy willingly reverted to that passage of Ecclesiasticus, where the writer describes Simon, shining "as the morning star," and "as a rainbow" on the temple of the Eternal. The sky soon cleared, and presented a midnight scene like that which Bloomfield has described so admirably:

> "——above these wafted clouds are seen
> (In a remoter sky, still more serene,)
> Others, detached in ranges through the air,
> Spotless as snow, and countless as they're fair;
> Scatter'd immensely wide from east to west,
> The beauteous semblance of a flock at rest,
> These, to the ruptur'd mind, aloud proclaim
> Their mighty Shepherd's everlasting name."

MILL-WORK.—Under this head we purpose noticing the simplest combinations of wheel-work which are employed in the construction of mills, and, under the articles WIND and WATER MILLS, complete views, both graphic and descriptive, will be given of their construction.

The business of a millwright is usually combined with the practical part of engineering, and much of the wind and water power formerly employed in giving motion to machinery is now superseded by the introduction of the steam engine. Indeed, without the agency of steam power, this country could in no shape compete with other manufacturing nations; so that, on account of the great importance of the steam engine as a prime mover, it will be advisable to devote a commensurate space to its illustration.

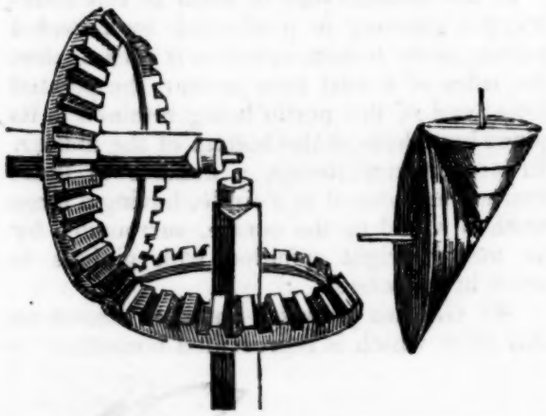
Various are the methods by which motion may be communicated from one part of a machine to another; and much of the skill of the millwright consists in his adapting certain methods to his particular purposes. Sometimes a simple cord, or a cord with pulleys, may be used. Levers, either simple or combined, are employed to communicate and also change the direction of the motion. Rods also are employed, which may be carried to a great distance by being connected together. But of all the modes of communicating motion, that by means of wheels is the most frequent. Wheels may be made to turn each other even by the simple contact of their surfaces when pressed together; or their circumferences may be formed into brushes with short thick hair, which enable them to turn each other with considerable force; or they may have cords, or straps of leather, or chains, passing from one to another; and at other times there are points or protuberances on the rims of the wheels. The most usual method, however, of making wheels drive each other, is by means of teeth. These are either cut into the substance of which the wheel is composed, when it is of metal; or formed at the same time as the rest of the wheel, when it is cast.

The proper method of shaping the teeth of wheels, so as to communicate the motion equally, and with as little friction as possible, is a matter of very great nicety, and has given rise to much study among mechanics. The ends of the teeth should be curves, but not parts of complete circles. They may be formed of the curve called the epicycloid, or of the involutes of circles, which are curves described by a point of a thread, which has been wound round the wheel while it is uncoiled.

A wheel which has teeth cut upon the circumferences, so as to project out in the plane of its face, is called a spur wheel; and, when the projection of the teeth is at right angles to the face of the wheel, and parallel to the axis, the wheel is called a crown or contrate wheel. Sometimes the faces of the two wheels are in the same plane, and consequently the axes parallel; and at other times the axes are at right angles to each other, one being a spur and the other a contrate wheel.

There is a mode of placing the teeth frequently resorted to, which consists in level-

ling the edge of the wheel, and cutting the teeth on the bevel, by which they may turn in each other, though variously inclined, and the teeth have also great strength. The principle consists in the cones rolling on the surface of each other, as in the annexed right-hand engraving; if their bases are equal, they will perform their revolutions in one and the same time.

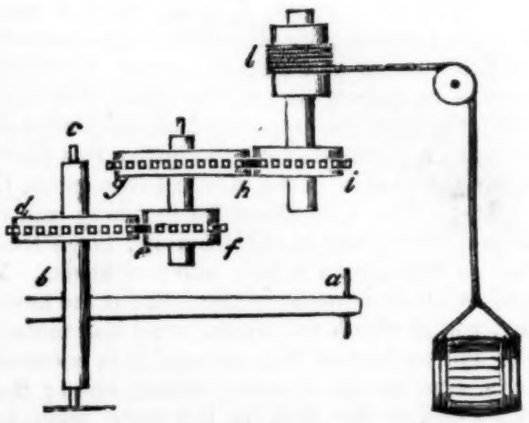


If the cones are fluted, or have teeth cut in them diverging from the centre, they are then called *bevel geer*. The teeth may be made of any dimension, according to the strength required; and it is of great use to communicate a motion in any direction, or to any part of a building. The bevel geer represented in the left-hand figure must be supported by a frame at the point where the pivots intersect each other. The frame is usually formed of iron or wood, and when the latter is employed the pivot-hole is of brass. The perpendicular shaft should always be made to revolve on a sharp point in the centre.

Hook's universal joint, (described at page 154, vol. ii,) may be applied to communicate motion instead of bevel geer, where the speed is to be continued the same, and where the angle does not exceed thirty or forty degrees and the equality of motion is not regarded; for, as it recedes from a right line, its motion becomes very irregular. This joint may be constructed by a cross, or with four pins fastened at right angles upon the circumference of a hoop, or solid ball. It is of great use in cotton mills, where the tumbling shafts are continued to a distance from the moving power.

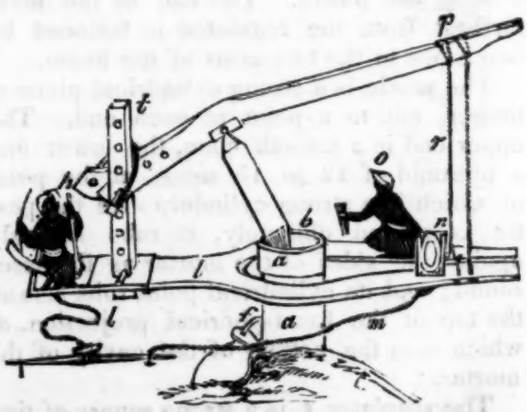
The employment of animal power in the simplest species of mill-work may be well illustrated by the accompanying sketch, in which a horse may be attached to a long lever, and thus made to raise a weight by a train of wheels and pinions.

The weight to be raised is suspended by a rope or chain which winds round the drum, *l*. On the same axis is placed a wheel, *i*, actu-



ated by another wheel, *g h*. The wheel, *d e*, gives motion to the whole, by the intervention of the small wheel at *f*. A horse at *a* may be considered as the prime mover, as the lever *a b* is on the axis *c*. Now, in this apparatus, there is a loss of power, but a gain in velocity.

The various modes of constructing mills for domestic, as well as manufacturing processes, will be explained hereafter, and we now purpose confining ourselves to a single example of the mode of employing animal power, in a way which, from its simplicity, might be adopted to a great extent in this country. There is a mill of a cheap and effective kind used in many parts of the East, which appears to have suggested the use of the ordinary snuff-mill. Indeed, it is, in some respects, superior to it. This mill, which is employed in the preparation of sugar, consists of a mortar, beam, lever, pestle, and regulator, as represented in the engraving beneath:



The mortar, *a a*, is a tree about ten feet long and fourteen inches over, which is sunk in the earth, so as to leave about two feet above ground. At the top is formed a conical cavity like a funnel, which ends in a hollow cylinder, with a hemispherical projection at the bottom, in order to allow the juice to run freely to the small opening that

conveys it to a spout, *f*, from which it runs into an earthen pot. Round the upper mouth of the mortar is a circular cavity, *b*, which serves to collect any of the juice that may run over from the upper end of the pieces of cane. A channel is cut to convey this juice down the outside of the mortar to the spout, *f*.

The beam, *i*, is about 16 feet long and 6 inches thick, and is cut from any large tree that is divided by a fork into two arms. A hollow circle is made in the fork for the mortar, round which the beam turns horizontally: the surface of this excavation is secured by a semi-circle of some strong wood; the other end of the fork is left quite open, in order that the beam may be changed without any trouble. The bullock driver sits on the undivided end, to which the cattle are yoked by a rope, *l*, from his end of the beam, and they are kept in the circular tread by another rope, *m*, which passes from the yoke to the forked end of the beam. A basket, *n*, is placed upon the forks to hold the cuttings of the cane, and the man, *o*, who feeds the mill, sits between this basket and the mortar. He takes care to place the pieces of cane sloping down the cavity of the mortar, just at the time that the pestle comes round; and after the pestle has passed, he removes those which have been squeezed.

The lever, *p*, is a piece of timber nearly as long as the beam. The thickest end, which is also the lowest, is connected with the undivided end of the beam by means of a regulator, *t*. A little way from the place where it is joined to the regulator, a piece of very hard wood is morticed into the lower side of the lever, and a smooth conical hollow is made in this piece, to receive the head of the pestle. The end of the lever furthest from the regulator is fastened by two ropes to the two arms of the beam.

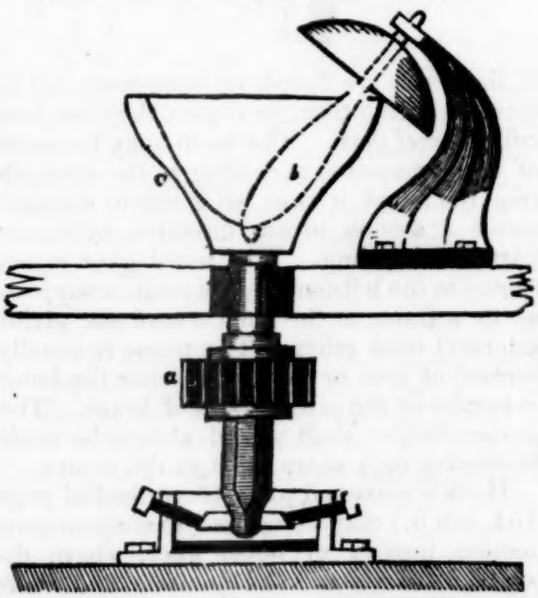
The pestle is a strong cylindrical piece of timber, cut to a point at each end. The upper end is a smooth cone, the lower end a pyramid of 12 to 15 sides, at the point of which is a strong cylinder. As the pestle is placed obliquely, it rubs strongly against the sides of the mortar as it passes round; and its cylindrical point rubs also on the top of the hemispherical projection, *d*, which is in the bottom of the cavity of the mortar.

The regulator, *t*, is a strong square of timber, which passes through the undivided end of the beam, and is secured below it by part of its circumference being left for cheeks. It is pierced by eight holes, and a pin is placed in the lowest hole, to prevent the regulator from falling when the strain is removed.

The canes with which the mill is supplied are cut into pieces six inches long. The mill goes night and day during crop time, and presses about fifty-six pots, or 218 gallons of juice, in that time. Two bullocks are used at a time, and as they are driven very fast, they are changed every time three pots of juice are expressed, and work no more that day.

In the manufacture of snuff in this country, the grinding is performed by a loaded pestle, made to turn round as it rubs against the sides of a cast iron mortar, the pointed lower end of the pestle being retained in its place by a hole at the bottom of the mortar. In large manufactories, a number of these mortars are placed in a circle, having a large toothed wheel in the centre, surrounded by as many upright spindles, with pinions to work in the wheel.

Mr. Gill has proposed an improvement on this plan, which is represented beneath:



The mortar, *c*, is in this arrangement made to revolve, and the pestle, *b*, is supported by a bracket firmly attached to the beam beneath. The pinion, *a*, rests on a conical axis, and communicates, as in the old arrangement, with the principal driving wheel.

Water-mills are of three kinds: ***Breast-mills***, ***undershot-mills***, and ***overshot-mills***, according to the manner in which the water is applied to the great wheel. In the first, the water falls down upon the wheel at right angles to the ***float-boards***, or bucket, placed to receive it. In the second, which is used where there is no fall of water, the stream strikes the float-boards at the lower part of the wheel. In the third, the water is poured over the top, and is received in buckets arranged round the wheel.

A less quantity of water will turn an overshot mill (in which the wheel has buckets instead of float-boards) than a breast-mill, where the fall of water seldom exceeds half the height of the wheel; so that, when there is but a small quantity of water, and a fall great enough for the wheel to lie under it, the bucket, or overshot-wheel, is always used; but, where there is a large body of water, with a small fall, the breast or float-board must be used. Where the water runs only upon a small declivity, it can act but slowly upon the under part of the wheel, in which case the motion of the wheel will be slow; and therefore the floats ought to be very long, that a large surface of water may act upon them, so that what is wanting in velocity may be made up in power; and then the cog-wheel may have a greater number of cogs in proportion to the rounds in the trundle, in order to give the mill-stone a sufficient degree of velocity.

It was the opinion of Smeaton, that the powers necessary to produce the same effect on an undershot-wheel, a breast-wheel, and an overshot-wheel, must be to each other as the numbers 2·4, 1·75, and 1.

Wind, which we may consider as the next substitute for animal power, appears to have been first employed to give motion to machinery in the beginning of the 6th century. The use of this species of mechanical force is, however, principally limited to the grinding of corn, the pressing of seed, and other simple manipulations, the great irregularity of this element precluding its application to those processes which require a continued motion.

A windmill with four sails, measuring seventy feet from the extremity of one sail to that of the opposite one, each being six feet and a half in width, is capable of raising 926 lbs. 232 feet in a minute, and of working on an average eight hours per day. This is equivalent to the work of 34 men, 25 square feet of canvass performing the average work of a day laborer. A mill of this magnitude seldom requires the attention of more than two men; and it will thus be seen that, making allowance for its irregularity, wind possesses a decided superiority over every species of animal labor.

The following very important errors have frequently been made by mathematicians and practical mechanics, in the estimation of the force of the wind or the water on oblique surfaces; they have generally arisen from inattention to the distinction between pressure and mechanical power. It may be demonstrated that the greatest possible pressure of the wind or water, on a given oblique surface at rest, tending to turn it in a direction perpendicular to that of the wind, is obtained when the surface forms an angle of about 55° with the wind; but that the mechanical power of such a pressure, which is to be estimated from a combination of its intensity with the velocity of the surface, may be increased without limit by increasing the angle of inclination, and consequently the velocity. The utmost effect that could be thus obtained would be equal to that of the same wind or stream acting on the float-boards of an undershot-wheel; but, since in all practical cases the velocity is limited, the effect will be somewhat smaller than this: for example, if the mere velocity of the sails or float-boards be supposed equal to that of the wind, the mechanical power will be more than four-fifths as great as that of an undershot wheel; that is, in the case of a windmill, more than four-fifths of the utmost effect that can be obtained from the wind. In such a case Maclaurin has shown that the sails ought to make an angle of 74° with the direction of the wind: but in practice it is found most advantageous to make the angle somewhat greater than this, the velocity of the extremities of the sails being usually, according to Mr. Smeaton, more than twice as great as that of the wind. It appears, therefore, that the oblique sails of the common windmill are in their nature almost as well calculated to make the best use of any hydraulic force as an undershot-wheel; and, since they act without intermission throughout their whole revolution, they have a decided advantage over such machines as require the sails or fans to be exposed to a more limited stream of the wind during one half only of their motion, which is necessary in the horizontal windmill, where a screen is employed for covering them while they are moving in a direction contrary to that of the wind: and such machines, according to Smeaton, are found to perform little more than one-tenth of the work of those which are more usually employed. The sails of a common windmill are frequently made to change their situation, according to the direction of the wind, by means of a small wheel with sails of the same kind, which turns round whenever the wind strikes on either side of it, and drives a pinion turning the whole machinery; the sails are sometimes made to furl or unfurl themselves, according to the velocity of the wind, by means of a revolving pendulum, which rises to a greater or less height, in order to prevent the injury which the flour would suffer from too great a rapidity in the motion, or any other accidents which might

happen in a mill of a different nature. The inclination of the axis of a windmill to the horizon is principally intended to allow room for the action of the wind at the lower part, where it would be weakened if the sails came too nearly in contact with the building, as they must do if they were perfectly upright. When it is necessary to stop the motion of a windmill, a break is applied to the surface of a large wheel, so that its friction operates with a considerable mechanical advantage.—[Partington's Scientific Gazette.]

Singularity of Records.—There is, perhaps, no one principle in human nature that leads to greater consequences, than the concentration of application to singular research.

But this, like every other principle, has occasionally strange and useless terminations, that may be called *lusus naturæ* in mortals. As an instance of this, I will present yon with the result of a man's labor for three years, eight or nine hours in a day, Sundays not excepted, to determine the verses, words, and letters, contained in the Bible.

Verses - - - -	31,173
Words - - - -	773,692
Letters - - - -	3,566,480

The middle and the least chapter is the 117th Psalm.

The middle verse is the 8th verse of the 171st Psalm.

Jehovah is named 6,855 times. The middle of these Jehovahs is in second Chronicles, fourth chapter and 16th verse.

The word *and* is found in the Bible 46,227 times.

The least verse in the Old Testament, is in first Chronicles, 1st and 10th verses. The least in the New Testament, 11th chapter of John, 35th verse.—[London paper.]

Genius in Prison.—It was in prison that Bœthius composed his excellent work on the 'Consolations of Philosophy;' it was in prison that Goldsmith wrote his 'Vicar of Wakefield;' it was in prison that Cervantes wrote 'Don Quixote,' which laughed knight errantry out of Europe; it was in prison that Charles I. composed that excellent work, the 'Portraiture of a Christian King;' it was in prison that Grotius wrote his 'Commentary on St. Matthew;' it was in prison that Buchanan composed his excellent 'Paraphrase on the Psalms of David;' it was in prison that Daniel Defoe wrote his 'Robinson Crusoe,' (he offered it to a bookseller for ten pounds, which that liberal encourager of literature declined giving;) it was in prison that Sir Walter Raleigh wrote his 'History of the World;' it was in prison that Voltaire sketched the plan and composed most of the poem of 'The Henriade;' it was in prison that Howler wrote most of his 'Familiar Letters;' it was in prison that Elizabeth, of England, and her victim Mary, Queen of Scots, wrote their best poems; it was in prison that Margaret of France (wife of Henry IV.) wrote 'An Apology for the Irregularity of her Conduct;' it was in prison that Sir John Pettas wrote the book on metals, called 'Fleta Minor;' it was in prison that Tasso wrote some of his most affecting poems. With the *fear* of a prison, how many works have been written!—[Ladies' Magazine.]

(The list may be extended. Pelico's Memoirs are a recent example.)

Automaton Juggler.—The Paris Journal des Debats gives us an account of a curious piece of mechanism invented by a watchmaker at Haute Ville. On an ornamented case, a juggler, about six inches in height, and dressed in Turkish costume, is represented seated beneath a canopy, with a little table before him; at his right is a stand, on which are placed three goblets and a drum. In the first place you hear a delightful overture executed by some internal mechanism; when this is finished, the little juggler, as a juggler should, rises and bows three times to the company: he then takes two of the goblets, and three silver balls, which he causes to pass successively from beneath one of the inverted goblets to the other, so rapidly as to deceive the eye, until they are all found at last under one. He then replaces the goblets, and strikes three times upon the drum, which opens and displays a little dancer, who flourishes upon the table with infinite grace, accompanied by music produced by mechanism, while the juggler beats the time, and expresses his approbation by significant gestures. The dancer then retires within the drum, and the juggler lifts the third goblet, beneath which is perceived a silver egg, from which issues a beautiful and richly colored little bird. This bird takes its station on the egg, claps its wings, and sings an air; when this is over, the juggler replaces the goblet, bows, and resumes his seat, and another air closes the exhibition. The artist was employed for the space of five years in completing this piece of mechanism, and sold it for 300,000 francs.

Utility the only Test of Merit.—Antiquity is worthless, except as the parent of experience; that which is useful is alone venerable; that which is virtuous is alone noble, and there is nothing so illustrious as the de-

dication of the intellect and the affections to the great end of human improvement and happiness: an end which will be the ultimate test and touchstone of all our institutions, by a reference to which they will be judged, and either perpetuated or swept away.—[Westminster Review.]

ADVICE ON THE CARE AND MANAGEMENT OF TOOLS.—From a new edition of the Cabinet Maker's Guide, we quote the following:

"The goodness of saws, chisels, and other edge tools, depends upon the quality of the steel, which should be uniform throughout, and it is always better to have them tempered too hard than too soft, for use will reduce the temper. If at any time you wish to restore the temper, and to perform the operation yourself, the best method is to melt a sufficient quantity of lead to immerse the cutting part of the tool. Having previously brightened its surface, then plunge it into the melted lead for a few minutes, till it gets sufficiently hot to melt a candle, with which rub its surface; then plunge it in again and keep it there until the steel assumes a straw color, (but be careful not to let it turn blue,) when that is the case take it out, rub it again with the tallow, and let it cool; if it should be too soft, wipe the grease off and repeat the process without the tallow, and when sufficiently hot, plunge it into cold spring water or water and vinegar mixed.

"By a proper attention to these directions, and a little practice, every workman will have it in his power to give a proper temper to the tools he may use.

"If a saw is too hard, it may be tempered by the same means; if you are near a plumber's shop, you may repeat the process conveniently and without expense, when they are melting a pot of lead.

"In other cutting tools you must wait till the steel just begins to turn blue, which is a temper that will give it more elasticity, and at the same time sufficient hardness."

THE PERSECUTIONS OF GENIUS.—The successful efforts of genius have not been more remarkable in the biography of eminent individuals, than the miseries which have often, during barbarous times, been endured by men of learning and scientific skill, through the ignorance of the very persons whom they intended to benefit. It is only, indeed, in the present age that we find the discoverers of new arts and sciences rewarded with the approbation of their fellows, if not with more substantial gifts; and in considering what has from first to last been the amount of the cruel persecutions of the learned, the existing generation can hardly believe it credible that so much wanton abuse of power can have been exercised. On this subject of melancholy interest, D'Israeli, in his Curiosities of Literature, has collected a variety of striking particulars. "Before the times of Galileo and Harvey (says this accurate writer), the world believed in the diurnal immoveability of the earth, and the stagnation of the blood; and for denying these, the one was persecuted, and the other ridiculed. The intelligence and virtue of Socrates were punished with death. Anaxagoras, when he attempted to propagate a just notion of the Supreme Being, was dragged to prison. Aristotle, after a long series of persecutions, swallowed poison. The great geometricians and chemists, as Gerbert, Roger Bacon, and others, were abhorred as magicians. Virgilius, Bishop of Saltzburg, having asserted that there existed antipodes, the Archbishop of Mentz declared him a heretic, and consigned him to the flames; and the Abbot Trithemius, who was fond of improving stenography, or the art of secret writing, having published some curious works on that subject, they were condemned as works full of diabolical mysteries. Galileo was condemned at Rome publicly to disavow his sentiments regarding the motion of the earth, the truth of which must have been abundantly manifest: he was imprisoned in the Inquisition, and visited by Milton, who tells he was then *poor* and *old*. Cornelius Agrippa, a native of Cologne, and distinguished by turns as a soldier, philosopher, physician, chemist, lawyer, and writer, was believed to be a magician, and to be accompanied by a familiar spirit in the shape of a black dog. He was so violently persecuted that he was obliged to fly from place to place; the people beheld him as an object of horror, and not unfrequently, when he walked, he found the streets empty at his approach: this ingenious man died in an hospital. When Urban Grandier, another victim of the age, was led to the stake, a large fly settled on his head: a monk, who had heard that Beelzebub signifies in Hebrew the God of Flies, reported that he saw this spirit come to take possession of him.

Even the learned themselves, who have not applied to natural philosophy, seem to have acted with the same feelings as the most ignorant; for when Albertus Magnus—an eminent philosopher, of the thirteenth century—constructed an automaton, or curious piece of mechanism, which sent forth distinct vocal sounds, Thomas Aquinas (a celebrated theologian) imagined it to be the devil, and struck it with his staff, which, to the mortification of the great Albert, annihilated the labor of thirty years. Descartes was horribly persecuted in Holland when he first published his opinions: Voetius, a person of influence, accused him of Atheism, and had even projected in his mind to have this philosopher burnt at Utrecht in an extraordinary fire, which, kindled on an eminence, might be observed by the seven provinces. This persecution of science and genius lasted till the close of the seventeenth century."

LOCOMOTIVE ENGINES ON COMMON ROADS. Mr. Byington, an ingenious mechanic of Pitts-

burg, is engaged in the construction of a locomotive steam engine, on an improved plan, and intended to be used on common or turnpike roads. The Pittsburg Statesman says, Mr. B. is confident that he has discovered an improvement by which a locomotive engine may be made to operate on such roads with perfect success. Let us hope that this confidence on the part of the builder is not premature or ill founded. If experience shall justify it, and he succeed in his undertaking, he will prove himself one of the benefactors of the age.—[Baltimore Patriot.]

SMOKY CHIMNEYS.—Among the many sufferings arising from the limited diffusion of science, that from smoky fireplaces is by no means the least. Independent of the direct inconvenience of smoke in the room, dangerous colds are often taken from hoisted windows or opened doors. What a beautiful picture of comfort is presented on entering, in cold December day, an apartment, the inmates of which have red and tearful eyes, and stand or sit shivering in currents of cold air! Count Rumford observes that the general fault of common chimneys is the greatness of the opening at the throat. The following is a condensed view of some of his rules:

"1. The *throat* of the chimney should be perpendicularly over *the fire*, as the smoke and hot vapor which rise from a fire naturally tend *upwards*. By the *throat* of a chimney is meant the lower extremity of its canal, where it unites with the upper part of its open fireplace. 2. The nearer the throat of a chimney is to the fire the stronger will be its *draught*, and the less danger of its smoking; since smoke rises in consequence of its rarefaction by heat, and the heat is greater nearer the fire than at a greater distance from it. But the draught of a chimney may be too strong, so as to consume the fuel too rapidly; and, therefore, a due medium must be fixed upon, according to circumstances. 3. That *four inches* is the proper width to be given to the throat, reckoning across from the top of the breast of the chimney, or the inside of the mantle, to the back of the chimney; and even in large halls, where great fires are kept up, this width should never be increased beyond 4½ or 5 inches. 4. The width given to the back of the chimney should be about *one-third* of the width of the opening of the fireplace in front. In a room of middling size, *thirteen inches* is a good size for the width of the back, and 3 times 13 or 39 inches for the width of the opening of the fireplace in front. 5. The angle made by the back of the fireplace and the sides of it, or covings, should be 135°, which is the best position they can have for throwing heat into the room. 6. The back of the chimney should always be built *perfectly upright*. 7. Where the throat of the chimney has an end, that is to say, where it enters into the lower part of the open canal of the chimney, *there* the three walls which form the two covings and the back of the fireplace should *all end abruptly*, without any slope, which will render it more difficult for any wind from above to force its way through the narrow passage of the throat of the chimney. The back and covings should rise 5 or 6 inches higher than the breast of the chimney. 8. The current of air, which, passing under the mantle, gets into the chimney, should be made *gradually to bend its way upwards;* by which means it will unite *quietly* with the ascending current of smoke. This is effected with the greatest ease and certainty, merely by *rounding off* the breast of the chimney, or back part of the mantle, instead of leaving it flat or full of holes and corners. Fig. 1 shows the section of a chimney on the common construction, in which *d e* is the throat. Fig. 2 shows a section of the same chimney altered and improved, in which *d i* is the reduced throat, four inches in the direction *d i*, and thirteen inches in a line parallel to the mantle."

Fig. 1.

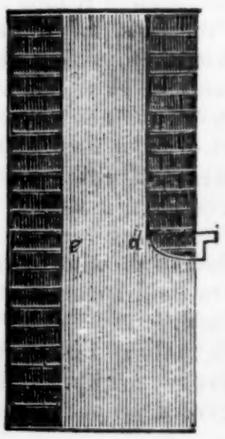
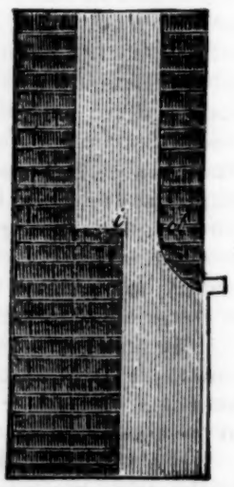


Fig. 2.



STATISTICS OF THE GLOBE.—The rapid population of the globe is estimated variously from 600,000,000 to 800,000,000; the geographical square miles at nearly 38,000,000, or 49,000,000 English square miles. The population to a square mile is, in France 61, Asia 27, Africa 10, America 3, Oceanica less than 1; the average of all about 17. The densest population in any whole province or state, is in Hamburg, where it is 1302 to a square mile. It is 980 in Bremen, 783 in Frankfort, 523 in Lubec, 464 in Lucca (Italy), 392 in Belgium, 314 in Saxony, 277 in Holland, 257 in Great Britain, the Sicilies 236, 208 in France, Austria 165, Prussia 155, Portugal 121, Denmark 119, Spain 101, Turkey 63, Greece 51, Russia 37.

In Asia some provinces have a population of from 200 to 500 to the square mile; Japan 139, China 42, Siam 57, English Indian Empire 185. In Africa, Morocco has 46, Tunis 45, and some of the interior kingdoms a little more. In America, Hayti has 36, Central America 12, Chili 10, United States 7½, Mexico 6.—[N. E. Farmer.]

Internal Improvements, No. III. By F. To the Editor of the American Railroad Journal, and Advocate of Internal Improvements.

Sir—The faculties of the human race may remain for generations in a state of torpor, but when once roused into action, they cannot easily be lulled again into inactivity and repose. Thus all innovations on old established customs, however plausible in appearance, are ever treated with distrust, and only admitted to confidence after a long series of successful experiments may have demonstrated the truth of the principles advanced. Then, as the eyes of men gradually open, and the cloud which had obscured their understandings is dispersed, they begin to marvel at the obtuseness of their own perceptions in not sooner comprehending the nature of the advantages predicted. How far this will be exemplified in the introduction of steam carriages on common roads, as a substitute for horse power, in the transport of goods and passengers, remains yet to be proved. Sceptics have not been wanting, to vociferate their timidity against its preferment, and pronounce its visionary character; and yet, the time may not be distant when the project will be hailed by the whole British nation as a confirmed blessing, and another step in the grand march of practical science. She may, ere long, be destined to witness her highways and byways, like her railroads and rivers, traversed from one end of the kingdom to the other, under the all-pervading influence of steam.

Experiments have already been made on a large scale, and with sufficient success to demonstrate to the minds of all those who feel an interest in the subject, the practicability, as well as capability, of the project, to realize all the hopes and expectations with which it has been endowed by its projectors. That it is destined, at no very remote period, to mark a new and important era in the means of intercourse among our transatlantic brethren, it would be folly to entertain a doubt; but, at the same time, we do not hesitate to say, that however applicable it may be to their present condition, the time is not yet arrived when its adoption as a matter of expediency can be recommended to this country. Our situation, in this respect, is in no way analogous to that of Great Britain. What would act as a benefit and blessing to her, would, in this case, prove a positive evil to us. But, before attempting to maintain this position, it will be necessary to state the principal objections already advanced against its introduction. They are as follows:—The insecurity of carriages so propelled; the liability of boilers to explosion; the annoyance of travellers by noise of machinery, and the escape of smoke and waste steam. These objections were in part answered before the House of Commons, during the examinations there held to collect information on this subject. It was then stated that the construction of the boilers was such that the steam could only act in very small quantities on any one part, and that even in the event of explosion, the danger would be comparatively trifling, and seldom or never attended by loss of life; that the escape of smoke might be prevented by the use of coke; and that the waste steam might be made to pass into the fire to increase the draft. It was further stated, that carriages properly constructed were capable of attaining a velocity of from ten to thirty-five miles per hour, on a level; that an acclivity of one in six had been surmounted at the rate of sixteen and a half miles per hour; and that a practical velocity of from twelve to fourteen miles per hour, where the minimum breadth of the wheel tire was three and a half inches, might be sustained without injury either to carriage or road.

How far these positions will hold in practice we are not at present prepared to say. But whatever may be the result in England, we need not hesitate to repeat the assertion that the period is very remote when the adoption of steam carriages will be deemed justifiable on the roads of America. It must be remembered that England is burthened with a large surplus population, and that every tax on agricultural produce, as a consequence, is accompanied by a proportionate degree of distress. Every suggestion, therefore, in the way of relief, commands immediate attention, and receives encouragement and support according as its merits may seem to justify. In Great Britain, there are more than a million of horses engaged in various ways in the transportation of goods and passengers; and it is estimated that it requires as much land for each horse as would on an average support eight men; or, in other words, the adoption of this new project would increase the capacity of the country to maintain eight millions of souls over and above what it is at present burthened with. Now, under these circumstances, it cannot be denied that the subject is deserving the attention of all philanthropists, not only as having a tendency to alleviate the distress of a large and meritorious portion of the population, but also as obviating the existing necessity for the abuse of that noble spirited animal, the horse. But these arguments cannot obtain in a country like our own, where the whole amount of population is small in comparison of the extent of territory; where large tracts of fertile land yet remain untilled, and extensive forests unlopped, by reason of the paucity of agriculturists. These blanks must be filled up before our harvests can possibly prove unequal to the demand made against them; and then it becomes a question of economy as combined with general convenience to all classes of persons interested.

As to economy, it is roundly asserted by our brethren on the other side of the water, that steam coaches can be run for from one-third to one-fifth the cost of post-coaches. This may be true enough—indeed it is believed to be so, from the fact that an ordinary coach, weighing two tons, can carry but eighteen persons, while a steam coach of the same weight may be made to carry double that number, and that the action of the wheels, where the tire is six inches wide, has a tendency rather to consolidate than cut up the road.

But another consideration of more importance to us claims attention, in the price of coke, which must necessarily enter largely in the expense of running all engines of whatever description, where steam is to be rapidly generated. It is a well established fact, that the price of this article is much greater in this country than in any other; so much so, that it becomes a question whether its use would not thereby be altogether unavailable. Should this prove to be the case, then other means must be resorted to for the destruction of the sublimated and volatilized matter always attendant on the combustion of coals in their natural state. This not admitting of any chemical combination, must be effected in some way by mechanical means. Before the House of Commons, it was stated that the effect might be produced by causing the smoke to pass through sand mixed with quicklime, by which the carbonic acid being absorbed, the carbonic oxyde and hydrogen was left in such a free state as to be combustible. This process, however, is altogether too slow in its operation to admit its practical application for any purposes of locomotion; and it is therefore only deserving of notice as an incitement to further discoveries.

But it may be asked, and with some show of reason, where are our extensive mines of anthracites? This species of coal is of such a nature as at once to do away with every objection that has been advanced against the use of other descriptions; for, not producing smoke of any kind, it may be used with impunity, without having recourse to artificial preparations. This would seem to be true enough, and to a certain extent is so—that is to say, the use of anthracite coals would most assuredly remedy the evil to which the public would be exposed from the escape of smoke, where bituminous coals were used in the generation of steam to propel carriages; but the difficulty unfortunately rests in the fact that steam cannot be generated with sufficient rapidity for this purpose, without the action of flame upon the boiler; and the combustion of this coal not producing any flame, recourse must be had to some extrinsic means for the attainment of that end. This end, it is true, has been particularly attained by experiment in the decomposition of water, by passing a jet, under the action of the engine, constantly over the bed of hot coals. But this experiment, though it may eventually be made to answer the purpose, does not as yet seem to have been sufficiently tested in practice to render it available in ordinary cases; and as we do not wish to indulge in speculations of any kind, we shall forbear to express an opinion on the subject until the results of more extended trials may be made known.

It requires, however, no great stretch of human foresight to predict that the introduction of steam carriages on common roads will be a signal to the abandonment of all ordinary modes of travelling. They must be exclusively adopted or not at all, and therefore it will be necessary for all persons, desirous of moving from place to place, to be dependent entirely on the public conveyances for its accomplishment. Now, it is a well known fact, that all farmers who inhabit mountainous districts, or such as are yet unpenetrated by either railroad or canal, must of necessity be their own carriers. The expense of maintaining one, two, or more horses, is comparatively trifling. They are absolutely necessary to the prosecution of their agricultural pursuits, and after their harvests are gathered in, they are equally useful in the transportation of the proceeds to market.

These observations naturally suggest themselves as objections to the introduction of this new mode of conveyance among us for a long time to come; and they are introduced here simply because we think that we have discovered a growing disposition among some of our speculators to embark in the project. Our necessities alone should dictate the period when this revolution ought to take place; and even then, where so many changes are to be made, so many prejudices to be overcome, and so many jarring interests to be reconciled, all the influence of legislative support will be requisite to establish it on a firm foundation.

This period, however, it is believed, has already arrived in England. She feels herself bending under a burthen which, unless soon lightened, will eventually bear her down. She feels the necessity of adopting some decided measures for the relief of the lower orders of society. With these feelings generally prevalent, it is not to be surprized at that her mechanics should take advantage of the first opportunity that offered a fair prospect of success, to start a fresh track, and open a new avenue to the resources of the country. The facilities afforded by the genius of McAdam pointed out the way; the hard and uniform surface of his roads suggested the practicability of the undertaking; and although we sincerely deprecate its immediate adoption here, we earnestly wish it all the success, in the land of its birth, that its undoubted merits have a right to claim.

F.

New-York, 8th Dec., 1833.

Undulating Railway.—A series of experiments have been some time in progress, on a part of the Liverpool and Manchester railway, for the purpose of ascertaining the practicability of a scheme suggested and very strongly entertained by Mr. Badnall, of impelling carriages upon a railway by means of a power derived from the inequalities or undnlations of the line. The directors of the railway liberally allowed Mr. Badnall the use of two engines, the Rocket and the Caledonian, and though the temporary defects of the former engine did not at first allow of the experiments being carried to the certainty that the projector desired, they were yet amply sufficient to justify his confidence in the principle. "I consider," says Mr. Badnall, "the results in practice to confirm most fully the advantages shown on the models, and I have not the slightest doubt that it will be found practicable to convey far greater loads from one summit of a curve to another, whose angles do not even exceed that

of the Sutton inclined plane, than any locomotive engine can move upon a level road."

There appears to us to be something extremely feasible in this plan; and being one which can be tested by actual experiment, no extraordinary credulity is involved in giving a serious consideration to its practical applicability. It rests upon one of the simplest laws of nature, which is within the daily experience of almost every individual, but heightened, by the facilities of the railway, into a greater efficiency of operation. We all know that a wheeled vehicle, or any other body, moving freely down a declivity, accumulates a degree of velocity within itself which will propel it a certain distance after it has ceased to be acted upon by the descent of the road. This momentum will be greater in proportion to the greater weight of the body, which is all in favor of the object to which Mr. Badnall purposes to apply it. In order to discover how far the impetus acquired in falling down one slope of an undulating railway would be available in impelling a train of carriages over the next, the experiment is very simple: a certain degree of velocity being given to a load at the foot of an ascent, sufficient to carry it to the summit, we have only to ascertain whether an equal degree of velocity could be given to the load by its own passage down a plane of the same inclination. For this purpose it is only necessary to allow the load to traverse the plane in a reverse direction, and ascertain the velocity with which it again passes the foot of the ascent. The experiments made upon the Sutton inclined plane have fully borne out the correctness of this test, and the result has been so clear and uniform as to leave no doubt as to the soundness of the principle.

Admitting the possibility that the use of steam may be ultimately superseded by this plan, the immense saving which would be accomplished in fuel, carriages, machinery, &c. fills an amazing space in the contemplation, and would be sufficient to counterbalance many attendant disadvantages. Among the principal of these would undoubtedly be the additional capital and labor required for the peculiar construction of such a line of railway, in which a level tract of country, so important a desideratum under the present method, would present one of the most formidable obstacles. We trust, however, that the subject will meet with that serious attention which it unquestionably merits, and in the mean time we publish, with Mr. Badnall's authority, the result of his experiments as recently made.

The following engineers were present, viz. Mr. R. Stephenson, senior, the Messrs. Dixons, Mr. Daglish, and Mr. Badnall, who agreed that the truth and validity of the principle would be effectually determined by the following test:

As great a velocity as possible being attained by the engine *before* reaching a given point on the inclined plane, the *time* was to be accurately ascertained which the train occupied in ascending from that point to a state of rest. The power being then reversed, the time was to be accurately measured which the train occupied in descending from a state of rest to the point from which it had previously ascended. Hence it was obvious, that if the descent was made in less time than the ascent, the velocity generated at the foot of the plane would be proportionably greater than the velocity of the ascending train at the same point, and, consequently, the demonstration would be clear, that the engine and train would not only have ascended to an elevation equal to that from whence it fell, but to a greater one, the extent of which would be in proportion to the velocity attained.

Experiment 1. The Liver engine, and a load of 13 waggons, (weighing in all about 72½ tons,) after traversing a distance of three-fourths of a mile to acquire a sufficient velocity, ran up the inclined plane 278 yards; the time occupied in performing the latter distance being 90 seconds.

Exp. 2. The power being reserved, the engine and train *descended* 278 yards, the time occupied in the descent, viz. from a state of rest to the point from which the time of ascent had been calculated, being only 50 seconds.

Exp. 3. The engine and train having traversed three-fourths of a mile to generate a sufficient velocity, ascended 278 yards in 75 seconds.

Exp. 4. The power being reversed, the descent of 278 yards was accomplished in 40 seconds.

Exp. 5. The ascent of 278 yards was made in 80 seconds.

Exp. 6. The descent of 278 yards was made in 49 seconds.

AVERAGE.

	Total space passed over to generate the velocity.	Time occupied in ascending 278 yards.
Exp. 1,	1,320 yards.	90 seconds.
Exp. 3,	1,320 do.	75 do.
Exp. 5,	1,320 do.	80 do.
Total,	3,960 do.	245 do.
Average,	1,320 do.	81⅔ do.

	Total space passed over in generating velocity on inclined plane.	Time occupied in descending 278 yards.
Exp. 2,	278 yards.	50 seconds.
Exp. 4,	278 do.	40 do.
Exp. 6,	278 do.	49 do.
Total,	834	139
Average,	278	46⅙

It is almost needless to add that these experiments have most fully confirmed the undulating principle, and proved, beyond all doubt, that a locomotive engine and load can traverse a curve or undulation whose two summits are of equal altitude with much greater rapidity, and, consequently, with far greater economy of *time* and *power*, than a level road of proportionate length.

Mr. Badnall having intimated his opinion, that if a velocity of twenty miles an hour were attained at the foot of the plane by two engines, it would be proved by experiment that an engine could move, from one summit of an undula-

tion to another summit nearly, if not quite, *double* the load which that engine was capable of moving on a level, it was determined by the gentlemen present to decide this important question in the course of a few days.

THE UNDULATING RAILWAY.—For the purpose of further testing this important principle, several experiments have been tried since our last publication, of which the subjoined is the result:

It was determined by the engineers who witnessed the last experiments, that another trial should be made to prove the possibility or otherwise of conveying on an undulating line double the load which the engine was capable of drawing, at a like velocity on the horizontal railway.

The only day on which it was thought this experiment could safely and satisfactorily be made was on a Sunday; in consequence of which, on Sunday week a train of loaded carriages, weighing 150 tons, exclusive of the two engines which moved them and their tenders, left Manchester for the Sutton inclined plane.

On this occasion it may, in truth, be said that there never was a more friendly assemblage of mechanical men. It is well known to some of our readers that the French Government have selected a body of the most eminent engineers in that country to visit England, with a view of acquiring all requisite information preparatory to the construction of the intended French lines of railway. These gentlemen, nine in number, were all present; the English engineers who attended being Mr. Robert Stephenson, senior, the Messrs. Daglish, Mr. Dixon, and Mr. Badnall, in addition to whom were nearly all the practical mechanics connected with the railway, and many others, (among whom was Mr. Case, of Summerhill, and Mr. Garnett, of Manchester,) who felt a deep interest in the result.

The following statement is an undeniable corroboration of the favorable opinion which we have before expressed on this subject.

Mr. Badnall had proposed, as an extreme test of the merits of the undulating principle, that meaning:

Experiment 1. Two engines, the Firefly and the Pluto, brought the whole train of waggons, (the length of the train was about 151 yards,) weighing 150 tons, exclusive of engines and tenders, to a given point at the foot of the Sutton inclined plane, the velocity attained at this point being about 19 miles per hour. The Pluto then left the train and the Firefly ascended with the load 575 yards in 116 seconds; the distance traversed by the two engines to generate the velocity before ascending being at least one mile.

Exp. 2. The power of the Firefly being reversed, the engine and load *descended* 575 *yards* in 74 *seconds*; the velocity attained at the foot of the plane being *far greater* than at the same point when *ascending*.

Exp. 3. The Firefly and Pluto having traversed 1 mile to generate a velocity of 15 miles an hour, and the Pluto then leaving the train, at the foot of the inclined plane, the Firefly and load ascended 315 yards in 90 seconds.

Exp. 4. The Firefly's power being reversed, the whole train descended 315 yards in 65 seconds.

Exp. 5. The same engines and load, working about 1¼ miles, attained a velocity of 18 miles an hour; the Pluto left as before, and the Firefly and load rose 457½ yards in 102½ seconds.

Exp. 6. The Firefly and train descended 457½ yards in 80 seconds.

N. B.—On this occasion some delay occurred in reversing the power, which will account for the comparative difference in time.

Exp. 7. The two engines, as before, attained a velocity of 18 *miles* an hour at the foot of the ascent, the Pluto then left the train, and the Firefly shut off her steam, the whole train then rose, *by momentum only*, 332 yards in 70 seconds.

Exp. 8. The train descended (the Firefly working) 323 yards in 66 seconds.

The preceding experiments undoubtedly prove two most important facts, not only that a locomotive engine can convey, on an undulating line, double the load which it is capable of conveying at the same velocity on a level, *but that it can accomplish* this by the employment of *only one half its power*, which last-mentioned fact was decided by the last experiment.

SUSPENSION RAILWAY.—We have frequently been asked how the Suspension Railway is constructed; and how, when constructed, it could be used to any purpose with but *one rail*. Of the suspension railway we had heard much said, but had seen no description from which a correct idea could be formed, and therefore could not give an answer. The great object of the Journal, however, being to furnish information to all who wish it, relative to all kinds of railways, we took measures to obtain, through a friend in Boston, from the patentee, Henry Sargent, Esq., such a description, accompanied with drawings, as will enable any person to understand the principle upon which this cheap and convenient mode of internal improvement is constructed. There is certainly much ingenuity displayed by the inventor, in the construction of his model; and although we are not altogether satisfied that the invention will prove of great importance in practice, yet we consider it well worth the attention of those engaged in the construction of railways, as we are every day more convinced that we are only at the *threshold* of a successful tide of experiment in the construction of railroads. We are, in truth, at this time only *beginning* to learn to construct railways. Twenty years will do for railways what the same period has done and *is now* doing for *steamboats*. Instead of costing *twenty* or *thirty* thousand per mile, and travelling 15 to 25 miles per hour, they will be constructed for one-half the money, and we shall be able to travel at the rate of twenty-five to forty miles per hour. This, we are aware, will, by some, be deemed visionary; yet

a moment's reflection upon the rapidity and extent of the improvements of this country for a few years past, will convince any one that the past warrants even greater expectations than is here predicted.

The *suspension* railway has not heretofore been properly brought before the public. We shall, however, endeavor to obtain, as we trust we shall be able, from the gentleman who has so obligingly furnished us with the following, further descriptions, with accounts of its performances, &c., by which a more correct opinion may be formed of its merits.—[American Railroad Journal.]

Suspension or Single Rail Railway.—Imperfect descriptions of this invention have been published in pamphlets and newspapers, in England and America; erroneous impressions, however, have existed in regard to it, which it is the object of the writer to remove. The erection of the Single Rail Railway in England, and similar experiments in this country, have demonstrated this invention to be practicable, and no one doubts its utility. The superior excellence of this Railway, in comparison with all others, lies in its economy; a point which, it cannot be denied, in the ardor of speculation, is not always sufficiently regarded. The very simplicity and cheapness of an article are not unfrequently the cause of its condemnation, since it is neither "dear-bought nor far-fetched:" considerations, which seemingly enhance the value of our possessions. All other advantages being equal, economy must turn the scale in favor of the Single Rail Railway. To avoid the effects of frost and snow, the foundations of all railways, *in this climate*, must be equally deep, and their tops more or less elevated. It is not perceived that this kind of railway is inferior to any other, in its capacity for the transportation of heavy loads; nor in those facilities, by which it accommodates itself to every purpose of transportation. It is manifest that no estimate of any railway, per mile, can be made, without a full knowledge of its location, and of the tonnage, *per wheel*, intended to be transported; for the more the weight is distributed, the lighter and less costly may the railways be. The Single Railway must always be less expensive, other things being equal.

Should the surface of the route be unequal, the plane of the rail may be maintained, by elevating it to a reasonable height on posts of unequal length. From this circumstance, it must appear to the most casual observer, that a great *additional* saving in embankments, culverts, bridges, drains, &c. is claimed for the Single Railway. It has been objected to the Single Railway, that it is occasionally elevated, for the reasons above stated. But is this a comparative objection? Is it not common to both, and to all? The double railway at Quincy passes over intervals, in some places, twenty feet deep; and the rails, and *horse path also*, are elevated accordingly. Yet the railway at Quincy was constructed expressly for the transportation of heavy masses of granite. All writers, on the subject of railways, have adverted to lateral pressure, as a point of great consideration. This effect is inseparable from the very nature of the double rails. But in Single Railways much less allowance is required for lateral pressure: hence it is believed that the single rail can carry more than the double, in proportion to the number of wheels employed; for friction is diminished, in proportion as the lateral pressure is taken away. This lateral pressure causes the flanges of the wheels to rub on the sides of the rails, and corresponding effects are produced, at all the axles of the wheels; for the load on the double rail is immediately upon the axles, communicating its impulses directly and entirely to them.

On the single rail, such is not the case: the load is placed at the ends of the bars, and all motion is necessarily diminished at the axles, which are very *short*, and may be made much *less* than usual, as they are not compelled to bear those shocks which result from lateral pressure. The late experiments in England have demonstrated the superior power of the Single Railway, for the carriage of heavy burthens, attributable, in a great measure, to the causes above recited.

The most perfect steadiness of motion is secured to the carriage, on the Single Railway, by the late additional improvement of the friction rail and rollers: being a slender rail or rod placed on one side only of the supporters, and which bears the pressure of a few pounds only, amounting to nothing more than a slight difference, in the two parts of the load, and causing the heavier side to bear lightly on the friction rail. This pressure amounts to nothing more than that which occurs in adjusting the loads of common carts and trucks, with this difference, that the pressure is maintained longitudinally in the one case, and laterally in the other. It has been supposed, that a precise equipoise of the two portions of the load was indispensable. This is by no means required: a *difference* may exist of two for one, as a leverage takes place, which prevents all ill effects from such cause.

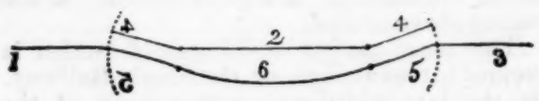
On the Single Railway, the load is more easily put on and taken off. The single rail may be more easily maintained in its proper position; the supporters and their foundations are not likely to be affected, by ordinary causes. The foundations are below the influence of frost, with several feet of heavy stone abutment on both sides, or packed with good gravel, unmixed with perishable earth. Should any change take place, which is not expected, as the pressure of the load is perpendicular, the carriage may still follow the inequalities of the single rail; whilst any considerable change in the position of either rail of the double railway must obviously impede all progress for a time, as effectually as it would be impeded on a common road by a fallen tree, or similar obstruction. This railway may be made of wood, stone, or iron: if wood, various means may be employed for its preservation.

It is not believed that, in point of facilities,

any railway is superior to this which is now recommended. As in other railways, so in this, hills are ascended and descended; roads are crossed, above or below, as they are crossed by canals, and by other modes; the passage of streams is effected on piles, or in *railway boats* particularly adapted to this object. It has been objected to the Single Railway, that, because of its elevated position, it must impede the common travel, which may lie across its path. We have already shown that this elevation is unavoidable, and that all objections, on this score, are general, and applicable to every species of Railway, *in this climate:* for all railways are elevated; the single, on the posts, and the double, on embankments and supporters also.

Crossing places are required, in both single and double railways, at eligible points, and can as easily be made in the former, as in the latter.

The passings or turnouts are effected with as much ease, on the single as on the double railway, as the following sketch may demonstrate:



Let the figures 1, 2, 3, represent the single elevated railway, with the portions 4, 4, thrown back, on simple but strong hinges or joints, which, when closed, form their respective parts of the railway, being fastened by a simple latch.

Figure 6 represents the turnout. 5, 5, two curved portions of the sideling or turnout, moved on strong joints; when closed, as in the sketch, connecting those parts of the rail 1, 3, with the sideling 6. A light carriage, travelling fast from 1 to 3, will at all times pass a slow carriage and take the lead of it, by turning on to the curved rail 5, to the sideling 6, to the main rail 3. The driver of the slow carriage having ample time, without stopping his carriage, to step forward and close the straight bar 4, and open the curved bar 5, with one motion of his hand, they being connected at bottom, (see dotted lines.) The slow carriage passes on to the main rail 2, and the driver replaces the bars as in the sketch, or they may be replaced mechanically; the fast carriage, coming up in the meanwhile, passes forward, the slow carriage being at No. 2. This mode is more particularly adapted to two Single Railways—one for going and the other for returning; but it may be used with advantage travelling both ways on one rail—and is similar to the mode adopted on the double rail, except that there are no cast iron plates with grooves, &c. which probably will not be very convenient in our frosty climate—especially as there are many of them at each sideling. The annexed drawing is a perspective view of the single elevated railway and carriage, which may be raised on supporters of two and a half or three feet on level ground, and more on an uneven surface, as circumstances may require.

The carriage cannot overturn, or incline farther than the friction rail, and may be of any ordinary breadth and length, and braced and strengthened as may be thought proper, and easily adapted to its particular use; and if the centre of gravity is below the top of the rails, the load may be placed higher than the top of the wheels, which, if the above principle be regarded, may be of the largest diameter; and even regardless of this principle, if the friction rail and rollers be employed.

If any objection exist, in relation to the Single Railway, such objection should be very formidable when opposed by considerations of great economy, superior advantages, and peculiar applicability to our own country.

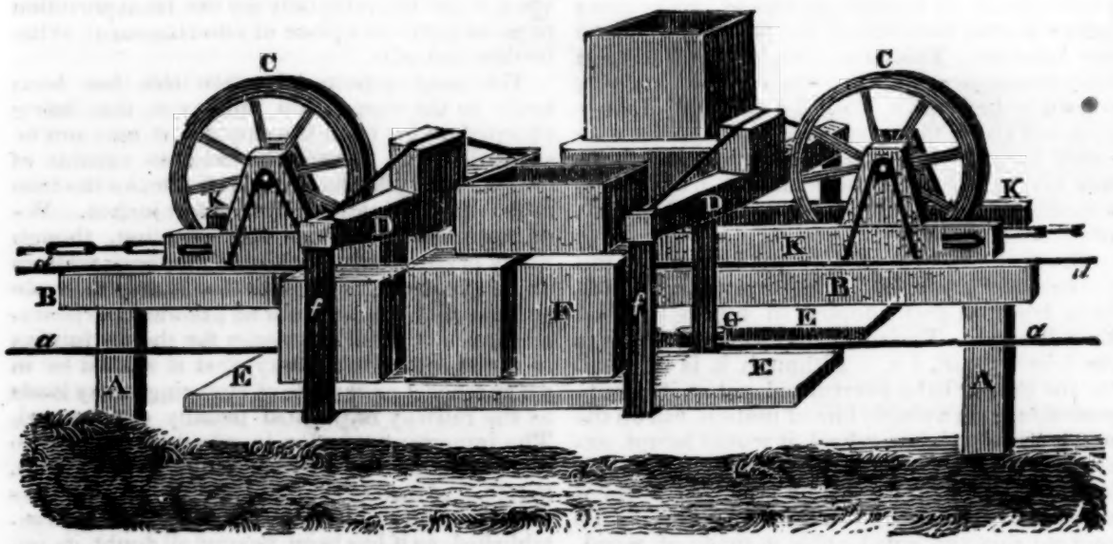
Boston, April 30th, 1827.

SUSPENSION RAILWAYS.—Many years ago, after the subject of railway transportation had begun to excite general attention both in England and America, the suspension or single railway was invented *originally* by Henry Sargent, Esq. of Boston, Mass. This invention (for, as the English writers say, it can with no more propriety be called an improvement than the plough can be called an improvement of the spade,) did not for many years attract the attention which its importance appears to deserve, and it remained for a long time without benefit to the public or advantage to the inventor and patentee. Circumstances, which we shall by and by refer to, took place about twenty years ago, which tended to make this railway better known; but at the same time Mr. Sargent found that he was in some danger of being deprived of his fame as inventor, and his right as patentee; and he consequently took some prompt measures to vindicate both.

Among other railways of Mr. Sargent's invention in the United States, there are now two in the county of Suffolk, Massachusetts: one at Chelsea, of a circular form, and a few hundred feet in extent, is used only for purposes of amusement, and is in fact a deviation from his original invention, and no more than an extensive model. The other, at East Boston, is a suspension railway, as lately improved, and has been commenced within a few months; and is not yet entirely completed. This railway is constructed over a marshy piece of ground, full of creeks and ponds, and much more unfavorable than the average surface of the country.

By the help of the plate, which, with the exception of the friction rail, *a a*, represents the railway and car, as first invented, we shall endeavor to convey some idea of the principles of the suspension railroad, and then to point out the improvements which have been subsequently made.

A A are the wooden posts driven or otherwise secured into the earth, upon which the rail is to be supported. The ground in the annexed plan presents a level surface, not requiring any difference in the length of the supporters. But where the surface is uneven, these



can be left of unequal length, and braced every three feet from the top of the rail, according to the undulations of the surface, so that the tops of the supporters shall be on the same level. There have been various expedients suggested for securing these posts in the ground, in order to diminish the tendency to incline from the vertical posture, by the weight and motion of the loads which they are destined to bear. The lower extremities of the posts should be sunk in transverse trenches to a depth of four or five feet, more or less, and placed upon a foundation of hard earth or stones. The sides should be filled up with rubble stones, or otherwise braced. The post should be supported, (in marshy soils,) by at least one strong timber, placed obliquely in the ground and bolted into it, by which it will be stiffened by the oblique timber, and secured from inclining in the opposite direction.

B B is the bearing rail, made of strong timber, of dimensions proportioned to the weight intended to be supported. This rail is to be firmly fixed upon the supporters with mortice and tenant. When the wheels C C are intended to be guided with flanges, it is advisable to have the top of the rail shod with iron, *d d*, in order to prevent the flanges from fraying, or, as it is called, brooming the sides of the rail, and thereby wearing it out and making it uneven. C C are the wheels, placed one before the other, in a direct line on the rail, and provided with flanges on either side, to keep them in position. From the axles of these wheels are suspended the horizontal bars or frame work, K K, to which the cars for passengers or merchandize are connected by the transverse bars D D, and strong, inflexible frame *f f*, so that the cars are balanced on each side of the rail, like the bags of a pack saddle. F is the loading placed on the cars in readiness for transportation. It might be objected by persons not acquainted with mechanics, that this method of transportation is unsafe, because there being but one line of wheels, the cars would be overturned, unless the load is very equally balanced on each side of the rail. It is of course better that the load should be so balanced, but it could very easily be shown in practice it is impossible that the cars can be overturned when the materials hold together. When one side is heavier than the other, a slight inclination of the heavier side takes place, and that is all; for as soon as the heavier side begins to incline, it approaches the centre of gravity, and is thus continually losing its tendency to incline, and cannot incline further than the supporters, as the car is longer, &c.; while, on the other hand, the lighter side is receding from the centre of gravity, and is consequently gaining power to balance the other by the leverage which takes place. We have frequently seen that a person carrying a single pail of water will extend his disengaged arm at right angles with his body, and by this simple instinctive motion, one arm alone is made to balance the other with a weight of twenty pounds at the end of it. A very great additional security is derived from the very low position of the centre of gravity, owing to the load being placed below the wheels, instead of above or on a level with them, as is the case in common carriages. It is also impossible that the car should be overturned in case of the breaking of the axles, for the load being on each side of the rail, and below the centre of gravity, the body of the car would fall but one-fourth of an inch, and slide on the rail, if in motion, and there be firmly supported. Such are the general principles of the suspension railway as originally invented by Mr. Sargent.

A few years ago the plan of a railway precisely similar in its nature was submitted to the British public by H. R. Palmer, Esq., and it has been generally noticed in English scientific works as Palmer's Patent Suspension Railway, no acknowledgement being made of Mr. Sargent's prior claim. It is impossible to say whether the English inventor had taken any hints, either directly or indirectly, from the American. We do not know that he had ever heard of it, but it is very certain that the latter could have had no possible assistance from the former, because he had demonstrated its

practicability by actual experiment, many years before it was mentioned on the other side of the Atlantic. This discussion, however, is of little consequence. Newton's argument, with regard to Leibnitz's alleged discovery of fluxions and the differential calculus, applies with equal force to this case. Whether Mr. Leibnitz invented it after me or had it from me, is a matter of no consequence, as second inventors have no rights.

Mr. S. has subsequently made several improvements upon his first invention, which have been in part adopted in his railway at East Boston. The most important of these is the friction rail, *a a*. Although it is impossible for the car to be overturned, yet as it is supported only on a single line of motion, but on the whole breadth of the wheel, it would be apt, except in cases where the load is composed of inert matter, and very nicely balanced, to have an oscillating vibratory motion on the rail. To prevent this the small rail *a a*, made of wood, is fastened on each side of the supporters A A, and to prevent friction from the sides of the car, a wheel *b*, on a vertical axis, is placed under the floor of the car, to run horizontally upon the rail. The pressure upon this rail is very trifling, amounting to much less than the difference of weight between the two sides of the loaded car, because the overloaded side having a tendency to descend in a perpendicular line, the oblique pressure upon the friction rail is smaller than the whole tendency of the loaded side to descend. The rail may therefore be of a small size, and can be furnished at a very trifling additional expense; and by means of it, the car, even with a shifting and varying load, will be kept as steady as if upon a double track.

Another great improvement has been suggested with regard to the wheels. If the wheels are kept on the main rail by flanges, as in the plate, it is absolutely necessary that the rail should be shod with iron, which causes a very great additional expense. If this is not done, the continual friction of the flange on the edge of the rail will cause it to fray or broom as before stated. To obviate this difficulty, the wheels may be made wider than the rail, without flanges, to run freely upon the smooth surface of the rail, and to keep their direction, guided by rollers, of which the place only can be seen in the plate, may be placed horizontally at *c c*, to run on the side of the rail, thus answering every purpose of the flange, but with a much smaller degree of friction, and with a saving of the whole expense of the iron guard for the rail.

A due regard being had to the principles above stated, the cars intended to be put upon the railway may be varied according to the nature of the articles to be transported, and the fancy or taste of the proprietor. The railway at East Boston is, as we have before said, built over a tract of marshy land of a peculiarly unfavorable nature. The supporters are piles driven through the marsh to a stratum of blue clay beneath, and strengthened by oblique braces. Being merely an experiment, the cars to be placed upon it are intended only for the transportation of passengers to a place of entertainment, at the farther end of it.

The only serious objection that has been made to the suspension railway is, that, being elevated so far from the ground, it may not be so sufficiently permanent, and so capable of bearing heavy loads, at a *rapid* rate, as the iron rails which are elevated only a few inches. We do not wish to discuss this question, though many persons, whose opinions in these matters are of great weight, believe that it may be made sufficiently permanent for all practical purposes. But it is not at all necessary for the usefulness of the suspension railway, that it should be in every respect as capable of enduring heavy loads as the railway now most usually constructed. The important question is, whether, taking into consideration the expense of its construction, the cost of transportation upon it will be less than upon an ordinary road. If this point is established, as it has been, beyond all doubt, its importance is manifest. There are many parts of the United States where the increase of population and of business calls for greater facilities of communication; yet the travel is not sufficient to support the enormous expense of the double iron railway. There are other sections so rugged and uneven, that whatever might be the amount of travel, it could not pay the expense of embankments, excavations, and other works necessary for attaining the level required for the road. In all such cases the suspension road, on account of its comparatively trifling expense, can be used to great advantage. The average cost of a suspension railroad, built with prudence and economy, extending over a country the surface of which presents no peculiar advantages or disadvantages, is about one quarter of that of the double track iron road now in use, and this difference is increased in proportion as the country, over which the road is to be constructed, is more rugged and uneven than usual. Now suppose that the suspension road is only capable of bearing one third of the momentum which the other road can bear, (and this is certainly a greater allowance than it would be necessary to make in practice,) yet the cost being one fourth that of the other, and its power one third, it follows, of course, that the suspension road would be much the most economical.

In a new country, therefore, where means are limited, it must be of immense advantage. Its merits have not hitherto been generally known. It has been but very little used in England, probably on account of the high price of timber, and on this side of the Atlantic we have been slow to adopt suggestions that have not been proved and tested by experiment. But it is now getting into more extensive favor in those parts of the country where timber is abundant. It will, no doubt, in a short time, prove a most important method of inland transportation.

Strength of Locust.—Experiments with seasoned locusts an inch in diameter resulted in suspending to it 20,000 lbs. nearly one-third the strength of iron.

State of Manufactures in America—Evidence of Mr. James Kempson, of Philadelphia, Cotton Manufacturer. [From the Factory Commissioners' Report in Great Britain.]

Most of our readers, doubtless, have heard of the struggle that has been going on between capitalists in England and the friends of amelioration of the condition of the working classes in that country, particularly of those who have not arrived at maturity, and are in fact in a much worse condition than most slaves in any part of the world. The philanthropists succeeded so far as to obtain a parliamentary commission of inquiry, which was followed up by the introduction of a bill into the House of Commons, regulating the hours of work in factories for all boys and girls under fourteen years of age, we believe. That bill passed the House of Commons, but the *House of Incurables*, (the Lords,) as they have been so well termed, thought fit to reject it.

In the course of the investigation, Mr. Kempson, of Philadelphia, was examined, and his testimony we now insert, and we are sure it will be perused with feelings of pride by all our readers.

With what extent of manufactures have you been conversant in America?—I have been acquainted with the manner of conducting manufactures in most of the manufacturing states.

What number of workmen do you employ in your manufactory?—About four hundred.

What is the lowest age of persons in your employment? None under nine.

Have you many about nine years of age? —We have a great many between nine and twelve. About one-fifteenth of the persons employed in the United States are under twelve years of age.

What is the utmost extent of your daily working hours?—The actual number of working hours averages throughout the year twelve hours of actual work; at some seasons it is nearly fourteen, and at others it is little more than ten.

Is the labor for fourteen hours often continuous for many successive days?—We change the period by the light. We never light up in the mornings, nor in the evenings, from the 20th of March to the 20th of September; and from the 20th of September to the 20th of March following, we work until eight o'clock of the evening.

Do the children work during the whole hours of work?—Yes; we never make any difference on account of age.

Have any complaints been made in the United States as to the propriety of such extent of labor for children?—There have been newspaper complaints, originating probably from the workmen who came from this country to the United States; but among our workmen there is no desire to have the hours of labor shortened, since they see that it will necessarily be accompanied by a reduction of their wages.

What proportion of the persons employed are natives of the United States?—Throughout New-England, which are considered the manufacturing states, above eight-tenths of the persons employed are natives of the United States.

Are many of the remaining two-tenths English workmen?—The greater portion of them; but, as a general rule, they do not like to take English workmen in the New-England factories.

Why do they not like the English workmen?—Because they are so dissipated and so discontented.

Is this their general character in the United States?—Yes; after they have been some time in the country, they are noted as the greatest drunkards we have. The wholesale price of whiskey is, with us, nine pence per gallon, and they appear not to be able to overcome the temptation. Our own workmen are *better educated, and more intelligent, and more moral, and refrain more from sensual indulgence.*

How does the discontent of the English workmen, of which you have spoken, usually manifest itself?—In the workmen becoming masters, in strikes, and demands for wages, almost always ill-considered, with which the master cannot comply, and which grievously interfere with his commercial operations; their ignorant expectations generate ill will and hostility towards the masters.

Are no jealousies entertained by the American workmen towards their masters?—In America we never hear the word master; they usually speak of the manufacturer by name, or as their employer, and view him rather as a tradesman to whom they dispose of their labor, than as a person having a hostile interest. There are no jealousies between American masters and workmen, of the nature of those which appear to prevail between the English workmen and their employers.

Are there no combinations to keep up wages in America?—None amongst the American cotton manufacturers.

Are there no combination laws?—None.

To what do you attribute this state of things among the American workmen?—To their superior education, to their moral instruction, and to their temperate habits.

Have you any national system of education?—We have public schools, supported partly by state funds, and partly by bequests. All children have the privilege of attending.

Do they, in point of fact, very generally attend in the manufacturing states?—They universally attend; and I think that information is more universally diffused through the villages and the whole community of the New-England states, than amongst any other community of which I have any knowledge.

What is the general view taken of these schools by the manufacturers and persons of wealth in America?—From their experience they deem them of the greatest importance to the welfare of the state. They are encouraged by the state governments and all the leading persons of the state.

How do the children whom they employ obtain education?—The manufacturers are always anxious that the children should absent themselves from the manufactory during two or three months of the year to attend the schools. The manufacturer very frequently suggests to the parents the necessity of the children being taken to school. The sending the child to school is generally an inconvenience to the manufacturer.

Is the inconvenience of the children going to school such as to increase the cost of production?—I do not think it does increase the cost of production. The only inconvenience is in the trouble of getting other hands. We think the advantage of their being educated more than counterbalances that trouble.

What is the nature of this national education?—It consists in reading, writing, arithmetic, grammar, and geography.

Do the workmen read much?—Yes; we have frequently a difficulty in keeping books out of the hands of some of them when they should be engaged in their work.

What sort of books do they usually read?—Voyages and travels are the most favorite reading with them. They are also great readers of newspapers, and some of the workmen take two or three.

Then what is the cost of each newspaper?—Less than 2d.

What wages do you usually give?—We employ them by the year. A person ten years old would get 3s. a week; a person twelve years old, 4s. a week; fourteen years, 5s.; sixteen, 6s.; eighteen, 8s. Those more advanced in years would earn 10s. The smaller children in the carding room are those who earn 3s. a week; those attending the drawing frames earn from 5s. to 6s.; those who attend the roving frames earn 8s. a week; girls attending the throstle-frames earn from 5s. to 8s.; machine makers earn about 5s. a day; mule spinners earn about 5s. a day; overlookers earn from 5s. to 6s. a day; assistant overlookers from 3s. to 4s. a day.

What do the men pay for board when they board with families?—From 6s. to 7s. per week.

What do young women pay?—Five shillings per week.

And children?—They generally board with their parents.

What is the description of fare usually obtained by the American workmen?—Nearly the same articles as those used by the more wealthy classes. They have as much meat as they wish twice a day; they have fruit pies at every meal; in short, as I have stated before a committee of the House of Commons, I have paid eight shillings a week for board, lodging, and washing, and live as well as I could live in equal lodgings in a village in England for two pounds a week.

What is the difference in the effects between fourteen and ten hours' work on the health of the persons employed, so far as you have observed in America?—When they worked twelve hours, the thermometer stood at 103°, and they were then more unhealthy than when they were working twelve hours in the winter season; but I believe that those who were in the mill enjoyed better health, both during summer and winter, than those who worked at agricultural employments, or than those who were idle. I state this from my own observation. I resided at the house of a medical practitioner, who had the practice of most of the persons who were employed at the mill, as well as of most of those who were employed in agriculture, and my own observation was corroborated by his reports, as to the sickness prevalent. Thus I received my impression of the superior healthiness of those engaged in the factory.

Are the American children stronger or weaker than the children of the English operatives?—The youngest American children are, I think, rather the strongest. Since November last I have been engaged in visiting the manufactories here, and I should say, that, on the whole, the children are rather stronger in America than they are here.

Would you call the English manufacturing children, as a body, unhealthy?—No; I

should almost think they are as healthy as the children in the agricultural districts. I have noticed that the children of a factory in a village usually look better than the children of a factory in a town. I should think this might be accounted for from the difference of the residences in the villages as compared with the residences in the towns, where they appear to work longer hours.

Does your experience in America of the short as compared with the long hours, enable you to form any judgment as to the probable effects upon the health or comforts of the workmen of a reduction of the working hours to ten in this country?—The climate is so different that I can form no judgment. The longest hours of our work are during periods of the most oppressive heat.

Do the children attend school at any particular period?—No; they attend during one period as much as another.

Do they select the times of the long or of the short hours?—I do not think they make any selection as to the hours of work. If they selected the time of the long hours they would have the night-work of the winter. They would, I think, as soon have the longer hours of the summer to avoid night-work.

What is the nature of your manufacture?—Spinning and weaving coarse yarn.

Is any of it for exportation?—Yes.

To what markets?—South America, West and East Indian markets.

Do you find that you can compete successfully with British manufactures of a similar kind in the same markets?—Yes; although we labor under some disadvantages that you do not.

What disadvantages?—One of our disadvantages is, that in the East India markets we have to pay a duty which you do not pay; and we have to pay six per cent. interest on the advance, which is considerably higher than you have to pay. A further disadvantage we labor under is, that whereas a large proportion of your manufacturers export their goods direct, and are therefore not subject to any commission on the shipment, our manufacturers never export on their own account, and the shipping merchant starts with a commission of five per cent. on the price which the manufacturer receives.

Have the goodness to explain the nature of the charge of five per cent. commission to which the article is subject prior to shipment?—The manufacturer sends his goods to a commission merchant at the shipping ports, who receives five per cent. for selling and guaranteeing.

And notwithstanding these drawbacks you can maintain the competition with us?—Yes; and not so only, but are gaining ground upon you, and have already excluded you from some markets.

From what markets?—Some of the Mexican and South American. Several of our largest establishments have large contracts pending for a long time forward for those markets, at prices which would not give a fair return to the British manufacturer, but are very profitable to our manufacturers.

You say this from having ascertained, during your visit to Manchester and other manufacturing districts in this country, the exact state of the relative prices?—Yes.

What are the present relative prices of yarn,—for instance, of No. 16?—No. 16, water twist, made entirely of good cotton, sells in the United States at 10½d. per lb.; in England, No. 16, yarn, made from a mixture of waste twists, and a small quantity of boweds, sells at 11d. per lb. The price of 10½d. in America is from the commission merchant, who receives 5 per cent. for selling it on eight months' credit; and the price of 11d. in England is on three months' credit from a manufacturer.

Do you consider the price of 10½d. to be remunerative to the American manufacturer?—Decidedly so.

And do you consider that you have equal advantages in weaving?—Yes.

Have you the means of showing what is the comparative cost of weaving in the United States and in this country?—Yes, I can show it by the following statement:

	United States			England.	
Interest on dressing machine,	£2	11		£1	12
Do. twelve power looms,	8	6	6 per cent.	4	10
Cost per annum of one horse power,	3	10		12	10, at 5 per cent.
Cost of dressing 3,756 pieces,	23	9		46	18
Cost of weaving,	125	4		156	10
American, 10½d. per piece,	£163	0	England, 11d.	£222	0

How do you account for the difference between £3 10s., which you state as the cost per annum of one horse power, and £12 10s. as the cost in England?—In America it is water power, which exists there in great abundance, at a very low rent, even in the best

situations; whereas in this country it is mostly steam power, or, if water power, at a very high rent.

What do you reckon will be the effect on the cost of production of your manufacture, if the working hours of your mills were, by an act of your legislature, to be reduced from an average of 12 to 10 hours?—They would be increased in price about ten per cent.

Have you the means of showing how the reduced hours of work would operate on the cost of production?—Yes, by the following statement:

Estimated value of the cotton manufacture of the United States—Wages, £2,087,400; cotton, £1,800,000; profit and interest, £1,529,266; annual value, £5,416,666. Now, supposing a legislative enactment to limit the working hours to ten, and in consequence of foreign competition the value of the goods must not be increased, and in order to make the same quantity he must employ one sixth more hands, and the interest on this increased investment must be deducted from the wages, for no other item can be reduced; taking the interest, wear and tear, at 8 per cent. upon this further investment, the amount will be £112,819.

£2,087,400 wages, as before
112,819

£1,974,581 wages after.

The number employed previous to this supposed alteration was 62,157, receiving upon an average annually £33 10s. The number increased to 72,572 would receive £27 4s. Supposing the workmen not reduced in their wages, the amount would stand: Wages, £2,429,998; interest on the investment, £112,819; cotton, £1,800,000; interest and profit, £1,529,266; total, £5,872,073.

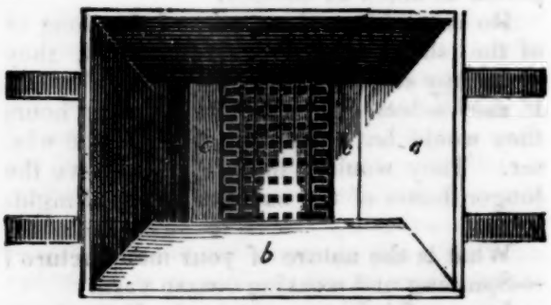
What, in your opinion, would be the effect of a compulsory limitation of the working hours in this country to ten instead of twelve, upon the manufactures of the United States?—It would tend much to their increase. I think we should not only be able to undersell you in markets abroad, but even in your home market.

Do you mean after paying the present import duty into this country of ten per cent?—Yes.

Do you not think that we should be under the necessity, in such a case, of adopting your tariff system?—Most undoubtedly, if you wished to preserve even your home market.

India Rubber.—More than fifty-two thousand pounds of caoutchouc, or India rubber, were exported into England in 1830, being nearly double the quantity brought during the preceding year. Its price is from 1s. 6d. to 2s. 3d. per lb. The duty upon it is 5d. per lb. The increase in the demand is to be attributed to the application of this substance as an article of general utility.

Curd-Breaker for Skim Milk Cheese.—We have heard of many curious experiments adopted by housewives, and some of them highly ludicrous, to facilitate the breaking of curd. This simple instrument is a happy substitute for every sort of expedient. With it any boy or girl can break the curd arising from the milk of eight or ten cows in fifteen minutes. It is not intended for the making of sweet milk cheeses, the curd of which should be broken very gently. It was invented by Mr. Robert Barlas, Gilmour Place, Edinburgh, and has been in use on some farms for several years past.



a, fig. 1, is a hopper of wood, 17½ inches by 14 on the top, and 10 inches in depth. *b* is a cylinder of hard wood 6¾ inches in length, and 3½ in diameter. It is studded with hard wood square pegs of a quarter of an inch in the side, cut square at the ends, and projecting three-eighths of an inch. There are eight teeth in the length, and fifteen in the circumference, of the cylinder, 120 teeth in all. It revolves on a round iron axle 12 inches in length, and is moved by the crank-handle *d* in fig. 2; *c c* are

two wedge-shaped pieces of hard wood, made to fill up in some degree the space between the side of the hopper and the cylinder. These pieces rest on a slip of wood nailed to the lower rim of the hopper, to keep them in their place. The face of these is studded with nine teeth of hard wood, similar to those on the cylinder, in a horizontal position, but so placed as to embrace those of the cylinder at opposite sides. The stand *e*, fig. 2, can be made of any length, to suit the breadth of the tub into which the curd is broken. The implement is used in this manner: place it over a tub, heap the hopper *a* with curd, and turn the winch *d* in ei-

ther direction, and the curd will fall quite small broken into the tub. While one hand is moving the machine, the other can press the curd gently down into the hopper. As cleanliness is a matter of the greatest importance in cheese-making, the internal parts of this machine being loosely put together, can easily be taken to pieces to clean. The cylinder axle rests on two hard wood plumber-blocks, *f*, fig. 2, one on each side, which slip out of their groove. They are held in their working position by the thumb-catch *g*, sunk flush with the bottom of the stand *e*, one over each plumber-block. The wedge-shaped pieces *c c*, fig. 1, come out. To prevent the curd working out of the sides of the axle, the cylinder is set a little at both ends into the sides of the hopper. The dotted lines in fig. 2 will give an idea how the internal part of the machine is constructed. Only one tooth is represented on the cylinder by the dotted lines, to show the position of the whole.—[Edinburgh Quarterly Journal of Agriculture.]

History of Chemistry. [Continued from Vol. II., page 251.]

"By arranging metals," says Dr. Ure, "according to the degree in which they possess the obvious qualities of unalterability, by common agents, tenacity, and lustre, we also conciliate their most important chemical relations, namely, those to oxygen, chlorine, and iodine; since their metallic preeminence is, popularly speaking, inversely as their affinities for these dissolvents. In a strictly scientific view, their habitudes with oxygen should perhaps be less regarded in their classification, than with chlorine; for this element has the most energetic attractions for the metals. But, on the other hand, oxygen, which forms one-fifth of the atmospheric volume, and eight-ninths of the aqueous mass, operates to a much greater extent among metallic bodies, and incessantly modifies their form, both in nature and art." Now, the arrangement we have adopted in the following list of these bodies will indicate very nearly their relations to oxygen. As we progressively descend, the influence of that beautiful element progressively increases. Among the bodies near the top of the table, its powers are subjugated by the metallic constitution; but among those near the bottom, it exercises an almost despotic sway, which Volta's magical pile, directed by the genius of Davy, can only suspend for a season. The emancipated metal soon relapses under the dominion of oxygen.

The number of metals at present known amount to thirty, if we except the bases of the alkalies and earths, and one or two other substances, which some individuals wish to rank among these bodies; but as they are not generally acknowledged to belong to this class of substances, we shall not include them in the following table:

	Names.	Spec. Grav.	Precipitants.
1	Platinum	21·47	Mar. ammon.
2	Gold	19·30	Sulph. iron; Nitr. mercury
3	Silver	10·45	Common salt
4	Palladium	11·8	Prus. mercury
5	Mercury	13·6	Common salt; Heat
6	Copper	8·9	Iron
7	Iron	7·7	Succin. soda, with perox.
8	Tin	7·29	Corr. sublim.
9	Lead	11·35	Sulph. soda
10	Nickel	8·4	Sulph. potash?
11	Cadmium	8·6	Zinc
12	Zinc	6·9	Alk. carbonates
13	Bismuth	9·88	Water
14	Antimony	6·70	Water; Zinc
15	Manganese	8·	Tartr. pot.
16	Cobalt	8·6	Alk. carbonates
17	Tellurium	6·115	Water; Antimony
18	Arsenic	8·35? 5·76?	Nitr. lead
19	Chromium	5·90	Nitr. lead
20	Molybdenum	8·6	Nitr. lead?
21	Tungsten	17·4	Mur. lime?
22	Columbium	5·6?	Zinc, or inf. galls
23	Selenium	4.3?	Iron; Sulphite amm.
24	Osmium	?	Mercury
25	Rhodium	10·65	Zinc?
26	Iridium	18·68	Zinc?
27	Uranium	9·0	Ferropr. pot.
28	Titanium	?	Inf. galls
29	Cerium	?	Oxal. amm.
30	Wodanium	11·47	Zinc
31	Potassium	0·865	Mur. plat.; Tart. acid.
32	Sodium	0·972	
33	Lithium		
34	Calcium		
35	Barium		
36	Strontium		
37	Magnesium		
38	Yttrium		
39	Glucinum		
40	Aluminum		
41	Thorinum		
42	Zirconium		
43	Silicium		

The first 12 metals in the table are malleable, as also the 31st, 32d, and 33d, in their solid or congealed state.

The first 16 are capable of being converted into oxides, which are neutral salifiable bases.

Those marked 17, 18, 19, 20, 21, 22, and 23, are capable of being acidified, by combination with oxygen.

Of the oxides of the rest to the 31st, very little is known.

The others form with oxygen the alkaline and earthy bases.

Having given as full a list of the metals as it is possible to obtain, and having stated pretty fully their general and characteristic properties, we shall now begin to describe them individually, and to state their particular properties. The malleable metals being the most valuable, as well as the most useful, we shall begin by describing them first.

Of Gold.—Gold seems to have been known from the very beginning of the world. Its properties and its scarcity have rendered it more valuable than any other metal.

It is of an orange red, or reddish yellow color, and has no perceptible taste or smell. Its lustre is considerable, yielding only to that of platinum, steel, silver, and mercury.

Its specific gravity is 19·3.

No other substance is equal to it in ductility and malleability. It may be beaten out into leaves so thin, that one grain of gold will cover 56¾ square inches. These leaves are only $\frac{1}{282000}$ of an inch thick. But the gold leaf with which silver wire is covered is only $\frac{1}{12}$ of that thickness. An ounce of gold upon silver wire is capable of being extended more than 1300 miles in length.

Its tenacity is considerable, though in this respect it yields to iron, copper, platinum, and silver. From the experiments of Sickingen, it appears that a gold wire 0·078 inch in diameter, is capable of supporting a weight of 150·07 lbs. avoirdupoise, without breaking.

It melts at 32° of Wedgwood's pyrometer.* When melted it assumes a bright bluish green color. It expands in the act of fusion, and consequently contracts while becoming solid more than most metals: a circumstance which renders it less proper for casting into moulds.

It requires a very violent heat to volatilize it; it is, therefore, to use a chemical term, exceedingly *fixed*. Gasto Claveus informs us, that he put an ounce of pure gold in an earthen vessel, into that part of a glass-house furnace where the glass is kept constantly melted, and kept it in a state of fusion for two months, yet it did not lose the smallest portion of its weight. Kunkel relates a similar experiment attended with the same result; neither did gold lose any perceptible weight, after being exposed for some hours to the utmost heat of Mr. Parker's lens. Homberg, however, observed that when a very small portion of gold is kept in a violent heat, part of it is volatilized. This observation was confirmed by Macquer, who observed the metal rising in fumes to the height of five or six inches, and attaching itself to a plate of silver, which it gilded very sensibly; and Mr. Lavoisier observed the very same thing when a piece of silver was held over gold, melted by a fire blown by oxygen gas, which produces a much greater heat than common air.

After fusion it is capable of assuming a crystalline form. Tillet and Mongez obtained it in short, quadrangular, pyramidal crystals.

Gold is not in the least altered by being kept exposed to the air; it does not even lose its lustre. Neither has water the smallest action upon it.

It is capable, however, of combining with oxygen, and even of undergoing combustion in particular circumstances. The resulting compound is an *oxide of gold*. Gold must be raised to a very high temperature before it is capable of abstracting oxygen from common air. It may be kept red hot almost any length of time without any such change. Homberg, however, observed that when placed in the focus of Tschirnhaus's burning glass, a little of it was converted into a purple-colored oxide; and the truth of his observations were confirmed by the subsequent experiments of Macquer, with the very same burning glass. But the portion of oxide formed in these trials is too small to admit of being examined. Electricity furnishes a method of oxidizing it in greater quantities.

If a narrow slip of gold leaf be put, with both ends hanging out a little, between two glass plates tied together, and a strong electrical explosion be passed through it, the gold leaf is missing in several places, and the glass is tinged of a purple color by the portion of the metal which has been oxidized. This curious experiment was first made by Dr. Franklin; it was confirmed in 1773 by Camus. The reality of the oxidizement of gold by electricity was disputed by some philosophers, but it has been put beyond the reach of doubt by the experiments of Van Marum. When he made electric sparks from the powerful Teylerian machine pass through a gold wire, suspended in the air, it took fire, burnt with a green-colored flame, and was completely dissipated in fumes, which when collected proved to be a purple-colored oxide of gold. This combustion, according to Van Marum, succeeded not only in common air, but also when the wire was suspended in hydrogen gas, and other gasses which are not capable of supporting combustion. The combustion of gold is

* According to the calculation of the Dijon academicians, it melts at 1298° Fahrenheit; according to Mortimer at 1301°.

now easily effected, by exposing gold leaf to the action of the galvanic battery. Dr. Thomson made it burn with great brilliancy, by exposing a gold wire to the action of a stream of oxygen and hydrogen gas mixed together and burning. Now in all cases of combustion the gold is oxidized. We are at present acquainted with two oxides of gold: the *protoxide* has a *purple* or violet, the *peroxide* a *yellow* color.

Of these, the *peroxide* is most easily procured; it is therefore best known. It may be procured in the following manner: equal parts of nitric and muriatic acids are mixed together,* and poured upon gold; an effervescence takes place, the gold is gradually dissolved, and the liquid assumes a yellow color. It is easy to see in what manner this solution is produced, for it is worthy of remark, that no metal is soluble in acids till it has been reduced to the state of an oxide. There is a strong affinity between the oxide of gold and muriatic acid. The nitric acid furnishes oxygen to the gold, and the muriatic acid dissolves the oxide as it forms. When nitric acid is deprived of the greater part of its oxygen, it assumes a gaseous form, and flies off in the state of *nitrous gas*. It is the emission of this gas which causes the effervescence. The oxide of gold may be precipitated from the nitro-muriatic acid, by pouring in a little potash dissolved in water, or even by lime water. It subsides slowly, and has a yellowish brown color, and sometimes, indeed, approaches to black. When carefully washed and dried, it is insoluble in water and tasteless. When this oxide is moderately heated it becomes purple. A stronger heat expels the whole of the oxygen, and reduces it to the metallic state.

The properties of the *protoxide* of gold are but little known. It is formed when the metal is subjected to combustion, or to the action of electricity, and likewise by exposing the peroxide to the proper degree of heat, or even by placing it in the rays of the sun. Its color is purple. Various preparations containing it are used in the arts, which will be noticed afterwards.

Hitherto gold has been united artificially to none of the simple combustibles except phosphorus. Hydrogen and charcoal are said to precipitate it from its solutions in the metallic state.

Sulphur, even when assisted by heat, has no action on it whatever; nor is it even found naturally combined with sulphur, as is the case with most of the other metals, yet it can scarcely be doubted that sulphur exercises some action on gold, though but a small one: for when an *alkaline hydro-sulphuret* is dropped into a solution of gold, a *black powder* falls to the bottom, which is found to consist of gold and sulphur, either combined or intimately mixed; and when potash, sulphur, and gold, are heated together, and the mixture boiled in water, a considerable portion of gold is dissolved. Three parts of sulphur and three of potash are sufficient to dissolve one of gold. The solution has a yellow color. When an acid is dropped into it, the gold falls down, united to the sulphur, in the state of a reddish powder, which becomes gradually black.

Gold does not combine, as far as is known, with any of the simple incombustible bodies.

But gold combines readily with the greater number of the metals, and forms a variety of alloys.

This metal is so soft that it is seldom employed in a state of purity. It is almost always mixed with small quantities of copper and silver. Goldsmiths usually announce the purity of the gold which they sell in the following manner: pure gold they suppose divided into 24 parts, called *carats*. Gold of 24 carats means pure gold; gold of 23 carats means an alloy of 23 parts gold, and one of some other metal; gold of 22 carats means an alloy of 22 parts of gold, and two of another metal. The number of carats mentioned specifies the pure gold, and what that number wants of 24 indicates the quantity of alloy. Thus gold of 12 carats would be an alloy containing 12 parts gold and 12 of some other metal. In this country the carat is divided into four grains; among the Germans into 12; and by the French it was formerly divided into 32.

Of Platina.—Platina, or platinum, was not known by chemists till the middle of the eighteenth century. Under this name, however, which is of Spanish origin, and signifies *little* or inferior *silver*, some white trinkets of little estimation were sold, before the metal was distinctly known. Antonio de Ulloa, a Spanish mathematician, who accompanied the members of the French academy, in their famous voyage to Peru, for the purpose of ascertaining the figure of the earth, first gave something like a precise notion of it, in the account of his voyage published at Madrid in 1748. It is observed, that Mr. Charles Wood, an English metallurgist, brought some of it from Jamaica in 1741. This gentleman related some experiments on this new metal in the Philosophical Transactions for 1749 and 1750.

* This mixture, from its property of dissolving gold was formerly called *aqua regia* (for gold among the alchymists was the king of metals); it is now called *nitro-muriatic acid*.

These first experiments, which announced very extraordinary properties, made a great noise in Europe, at a period when the discovery of a metal, particularly one so singular as this appeared to be, was a phenomenon beyond what any one had dared to hope. The great chemists of Europe were then eager to examine platina, and investigate its distinguishing characters. Scheffer, a Swedish chemist, gave the first accurate series of experiments on this metal, in the Memoirs of the Academy of Stockholm, in 1752; in consequence of which, he ranked this metal near gold for its properties, and called it *white gold*. Lewis, an English chemist, to whom we are indebted, among other things, for a history of silver and gold, very complete for the time, made a very extensive and regular series of experiments on platina, which he published in the Philosophical Transactions for 1754. In the Memoirs of the Academy of Berlin for 1757, Margraff gave an account of his experiments on this metal. All these early labors were collected and compared by Morin, in a work he published in France, in 1758, under the title of *Platina, White Gold, or the Eighth Metal*. This is a methodical compilation of all that had been done previous to that period.

After these researches, already very numerous, Achard, Guyton, Lavoisier, and Pelletier, successively published methods of obtaining platina pure, and of fusing it, and new information respecting its combinations.

From these combined labors we have acquired a considerable knowledge of the properties of platina, though there are still many things desirable for completing the history of this metal. The pneumatic system has done nothing with regard to platina, except teaching us to place it on a level with gold, in respect to its difficult oxidation, its little affinity for oxygen, and its consequent unalterability by the majority of other substances.

Platina, when purified, is of a less beautiful white than silver, and verging a little towards the grey color of iron. When burnished, it has a blackish tint, and not the white lustre of silver. Its unpolished parts are somewhat grey and dull. Its appearance is not so brilliant and pleasing as that of silver, or gold; and most men, though likely to confound it with other metals, would not form from the sight of it the same idea as of those two precious metals which attract their eyes and excite their admiration, or attach to it the same value.

This metal is the most dense and heavy of all natural substances. When it is slightly hammered or forged, its specific gravity is 21·5, and after being well hammered it is 23.

The elasticity of platina appears to be pretty considerable. Its ductility is great; though it is far from being easily wrought, it is reduced to very slender wires, and very thin leaves. Guyton gives it the second rank in this respect, placing it between gold and silver. It is easily bended, and the resistance and cohesion of the plates fabricated of it will, at some future period, admit a great number of uses to be made of it of high importance. The same chemist made the most accurate experiments on its tenacity, or the cohesion of its particles. In this point, he assigns it the third rank, after iron and copper, and before silver and gold.

Platina, like all other metals, heats quickly, and is a very good conductor of caloric. Borda found that its dilatation is $\frac{1}{92000}$ to a degree of Reaumur's, and $\frac{1}{110000}$ to a degree of the decimal thermometer. Of all metals it is most intractable in the fire and the most difficult to fuse. It goes beyond iron and manganese in this property. Guyton estimates its fusibility at a degree yet unknown, or beyond the utmost limit of Wedgwood's pyrometer. In fact, the greatest fire produced by our furnaces scarcely soften, perceptibly, the platina, in grains. At the most extreme degrees of heat we can only agglutinate these grains together, without imparting to them a true or strong adhesion, since they may be separated by hammering. Macquer and Baume kept several in a continued line, exposed to the constant and violent heat of a glass-house furnace; and these grains only stuck slightly to each other, for they were afterwards separated by the hand. They perceived their color became very brilliant, when they were at a white heat. On exposing the same grains of platina, well purified, to the focus of the burning lens of the Academy, the portions placed in the centre of the focus smoked, melted at the end of a minute, and formed an homogeneous button, white and brilliant, very ductile, and capable of being cut with a knife. Guyton likewise succeeded in fusing small portions in a crucible, by the help of his reducing flux, composed of eight parts of pounded glass, one of calcined borax, and half a part of charcoal, and employing for this operation Macquer's wind furnace. Lavoisier also fused small portions of platina in a cavity on charcoal with a blast of oxygen gas. After all these trials, there is nothing more easy than to procure little buttons of this metal, thus melted; but they are in such small masses that it is impossible to employ them in decisive experiments, and we may still say that

no real and useful fusion of platina has been obtained; since, when treated by the ordinary means, it is impossible to fuse it in such a quantity as allow us to examine its properties, and employ it in experiments capable of rendering us acquainted with them. Accordingly it will appear farther on, that, to apply it to the uses already made of it, the fabrication of plates, bars, wires, vessels, &c. it has been necessary to fuse it by the help of some alloys, and separate it afterwards by forging from the metals united with it.

Platina is a very good conductor of the electric fluid and galvanism. Its power in this respect has not been compared with that of other metals, but it appears to be very great. It has neither smell nor taste, in which it resembles silver and gold.

Platina has hitherto been found no where except in the gold mines of America, particularly in that of Santa Fe, near Carthagena, and in the bailiwick of Choco, in Peru. It is collected in the form of little grains, of a livid gray or white, the color of which partakes of those of silver and iron. These grains are mixed with several foreign substances; among them are found gold dust, blackish ferruginous sand, grains that appear through the lens scorified like the slag of iron, and some particles of mercury.

On examining the grains of platina with a lens, some appear angular, and others rounded or flattened like some pebbles. They may be flattened under the hammer, but some fly to pieces, and these frequently appear hollow within, and contain portions of iron and a white powder. To these small grains of iron must be ascribed the property of being attracted by the magnet, observed in the grains of platina, though well separated from the ferruginous sand among them. To obtain the purest and largest grains of platina, they are sorted by hand, and the gold dust, quartz, sand, and iron, are separated from them.

It is probable that platina is not found in the earth as it is brought to us, and as it is seen in mineralogical collections. The form of grains which it exhibits is owing either to the motion of the water by which it is carried down from the mountains into the plains, or to the grinding of the mills, through which the ores of gold with which it is mingled in the native state are passed. Sometimes pretty large pieces of it have been found. No naturalist has yet described the situations or varieties of ores of platina. It is at present the least known of all metals, and perhaps the only one which, being found hitherto only in one state, has been likewise discovered but in one single country. Platina is very distinguishable by its form, color, and specific gravity. As it is always mixed with sand and iron, and frequently with gold and quicksilver, beside the sorting by hand already mentioned, by means of which Tillet found some grains of this metal embedded in a quartz gangue, different processes are employed for its purification. It is heated red hot to volatilize the portion of mercury left by the amalgamation, by means of which gold was obtained from it. Iron is separated from it by the magnet, which frequently takes up with this attractable metal little fragments of platina. The grains are also heated with muriatic acid, which dissolves and takes up the iron. Bergman has remarked that platina loses 0·05 of its weight by this operation. After this nothing remains but the platina and the gold, both of which are to be dissolved in nitro-muriatic acid; and the proportions of the two metals may be found by precipitating the gold by sulphate of iron, and carefully weighing the precipitate, which, as we have before observed, is in a metallic powder.

As to operations in the great way, there is no one yet settled or practised. The Spanish government, having found that its miners debased gold with platina, and that it was difficult to discover the fraud on account of the specific gravity and unalterableness of this compound, is said to have shut up the mines of platina; but this is an improper expression, which requires to be explained so as to leave no ambiguity or uncertainty. It appears that platina, being always found mixed with gold ore, and both being disseminated in the native state in the same gangue, it is impossible that the mines of platina can have been shut; but as fast as this metal, which does not dissolve like gold in quicksilver, is extracted and separated, it is thrown away, or set apart, so that it is no longer met with in trade as formerly. Hence it is, that the mode of treating it in the large way has made no progress, and that no work in this new branch of metallurgy has hitherto been erected.

Accordingly, what belongs to the metallurgy of platina is nothing more than a series of operations on a larger scale than those of a simple assay, though on a much less than the usual metallurgic operations. It is by these that Carrochez, Jeannety, Chabanon, Wollaston, and several others, have accomplished the fusion, particularly by the help of arsenious acid, or what is called white arsenic, of some considerable quantities of platina; they have hammered and forged it by repeatedly heating and soften-

ing it, so as to deprive it by little and little, and at length completely, of the arsenic which rendered it fusible, and preserved its continuous and connected form, so as to admit of its being flattened, fashioned on moulds, and drawn into wire. It is by a similar operation that it has been brought to the greatest purity, reduced to the common state of other metals, and made to assume forms which may render it useful for various purposes.

As the different processes employed by most of the artists above mentioned for purifying, fusing, and forging platina, have not yet been described, we shall here state one of the simplest which has yet been employed. Dissolve the grains in diluted nitro-muriatic acid with as little heat as possible. Decant the solution from the black matter which resists the action of the acid. Drop into it a solution of *sal ammoniac*. An orange yellow colored precipitate falls to the bottom. Wash this precipitate; and when dry, expose it to a heat slowly raised to redness in a porcelain crucible. The powder which remains is platinum nearly pure. By re-dissolving it in nitro-muriatic acid, and repeating the whole process, it may be made still purer. When these grains are wrapped up in a thin plate of platinum, heated to redness, and cautiously hammered, they unite, and the whole may be formed into an ingot.

It cannot be combined with oxygen, and converted into an oxide, by the strongest artificial heat of our furnaces. Platinum, indeed, in the state in which it is brought from America, may be partially oxidized by exposure to a violent heat, as numerous experiments have proved; but in that state it is not pure, but combined with a quantity of iron. It cannot be doubted, however, that if we could subject it to a sufficient heat, platinum would burn, and be oxidized like other metals: for, when Van Marum exposed a wire of platinum to the action of his powerful electrical machine, it burnt with a faint white flame, and was dissipated into a species of dust, which proved to be the oxide of platinum. By putting a platinum wire into the flame produced by the combustion of hydrogen gas mixed with oxygen, he caused it to burn with all the brilliancy of iron wire, and to emit sparks in abundance.

To obtain the oxides of this metal, it is necessary to have recourse to the action of an acid. When the deep brown solution of platinum in nitro-muriatic acid is treated with lime water, a yellowish brown powder falls. Dissolve this powder in nitric acid; evaporate to dryness, and apply a heat sufficient to drive off the acid. The brown powder which remains is the peroxide of platinum. It is tasteless and insoluble in water. When heated to redness, the oxygen is driven off, and the oxide reduced to the metallic state. One hundred and fifteen parts of oxide, by this treatment, leave 100 parts of metal.

If the heat in this experiment be very cautiously raised, the oxide, before it is reduced, assumes a green color. This change is occasioned by the separation of a portion of the oxygen. The green colored powder is, according to Chenevix, a protoxide of platinum.

The action of the simple combustibles on this metal is not more remarkable than their action on gold.

Neither hydrogen nor carbon have been hitherto combined with it.

Phosphorus unites with it easily, and forms a *phosphuret*. By mixing together an ounce of platinum, an ounce of phosphoric glass, and a drachm of powdered charcoal, and applying a heat of about 32° Wedgewood, Mr. Pelletier formed a *phosphuret* weighing more than an ounce. It was partly in the form of a button, and partly in cubic crystals. It was covered above by a blackish glass. It was of a silver white color, very brittle, and hard enough to strike fire with steel. When exposed to a fire strong enough to melt it, the phosphorus was disengaged, and burnt on the surface. He found, also, that when phosphorus was projected on red hot platinum, the metal instantly fused and formed a phosphuret. As heat expels the phosphorus, Mr. Pelletier has proposed this as an easy method of purifying platinum.

Platinum cannot be made to unite to sulphur by heating them together. In this respect it resembles gold; yet there seems to be an affinity between the two substances, for when the metal is heated with a mixture of potash and sulphur, it is corroded and rendered partly soluble in water, as was proved by the experiments of Lewis and Margarf. And when sulphuretted hydrogen gas is passed into a solution of platinum in an acid, the metal is thrown down in dark brown flakes, apparently in combination with sulphur. Indeed, if we believe Mr. Proust, a sulphuret of this metal occurs sometimes mixed with native platina.

Platinum, as far as is known, does not combine with the simple incombustibles.

It combines with most of the metals, and forms alloys, which were first examined by Dr. Lewis.

Dr. Lewis found that gold united with

platinum when they were melted together in a strong heat. He employed only crude platina; but Vauquelin, Hatchett, and Klaproth, have since examined the properties of the alloy of pure platinum and gold. To form the alloy, it is necessary to fuse the metals with a strong heat, otherwise the platinum is only dispersed through the gold. When gold is alloyed with this metal, its color is remarkably injured: the alloy having the appearance of bell metal, or rather of tarnished silver. Dr. Lewis found that, when the platinum amounted only to one-sixth, the alloy had nothing of the color of gold; even one-forty-second part of platinum greatly injured the color of the gold. The alloy formed by Mr. Hatchett of nearly eleven parts of gold to one of platinum, had the color of tarnished silver. It was very ductile and elastic. From Klaproth we learn, that if the platinum exceed one-seventeenth of the gold, the color of the alloy is much paler than gold; but if it be under one-seventeenth, the color of the gold is not sensibly altered. Neither is there any alteration in the ductility of the gold. Platinum may be alloyed with a considerable proportion of gold, without sensibly altering its color. Thus an alloy of one part of platinum with four parts of gold can scarcely be distinguished in appearance from pure platinum. The color of gold does not become predominant till it constitutes eight-ninths of the alloy.

From these facts it follows, that gold cannot be alloyed with one-tenth of its weight of platinum, without easily detecting the fraud by the debasement of the color; and Vauquelin has shown, that when the platinum does not exceed one-tenth, it may be completely separated from gold by rolling out the alloy into thin plates, and digesting it in nitric acid. The platinum is taken up by the acid, while the gold remains. But if the quantity of platinum exceeds one-thirtieth, it cannot be separated completely by that method.

Some trinkets and utensils for the table have already been made of platina; but though they have the advantage of being unalterable and infusible, they have the real defect of not possessing a fine color, and are at the same time very ponderous. Platina, therefore, can be employed only for small and slender instruments, capable of being exposed to several corrosive matters, and to the air, without being altered by them; but this use is confined within narrow bounds.

By mixing it with copper and arsenic, in various proportions, mirrors for telescopes have been fabricated of it, which will never experience any alteration in their polish, and which unite with a bright and perfectly uniform polish of surface, a complete incapability of being altered by any possible agent.

Platina also promises the greatest and most important advantages in mechanics, and particularly in the delicate art of making time-pieces. The construction of a great number of machines will gain by the acquisition of this metal, which may be substituted in numerous cases for copper, iron, and even silver.

History of Astronomy—its various Systems.

[Continued from Vol. II, page 190.]

THE SOLAR SYSTEM.—The Solar, or true system of the world, as already observed, was taught by Pythagoras; but afterwards lost till the time of Copernicus, who again revived it, and from this circumstance it is often called the Copernican System.*

In this system, the Sun is placed nearly in the centre of the orbits of all the planets and comets; and in these orbits they perform their revolutions round the Sun in their respective periodic times. The number of planets at present known to belong to the solar system is 29, of which 11 are Primary, and 18 Secondary.

The Primary planets are those that circulate round the Sun as their centre, viz. Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus or Georgium Sidus, Ceres, Pallas, Juno, and Vesta. See the figure on the following page.†

The first six were known to the ancients, and are therefore called the *old* planets. The last five have been discovered since the year 1781, and are often called the *new* planets.

Those planets that have their orbits included within the Earth's orbit, are called *Inferior*, and those without the orbit of the Earth are called *Superior* planets.

The Moon is a secondary belonging to the Earth, and circulates round it while the Earth continues its annual course round the Sun. Jupiter has four secondaries or satellites revolving round him; Saturn has seven; and Uranus has six.

The orbits or paths in which the Primary Planets perform their revolutions round the

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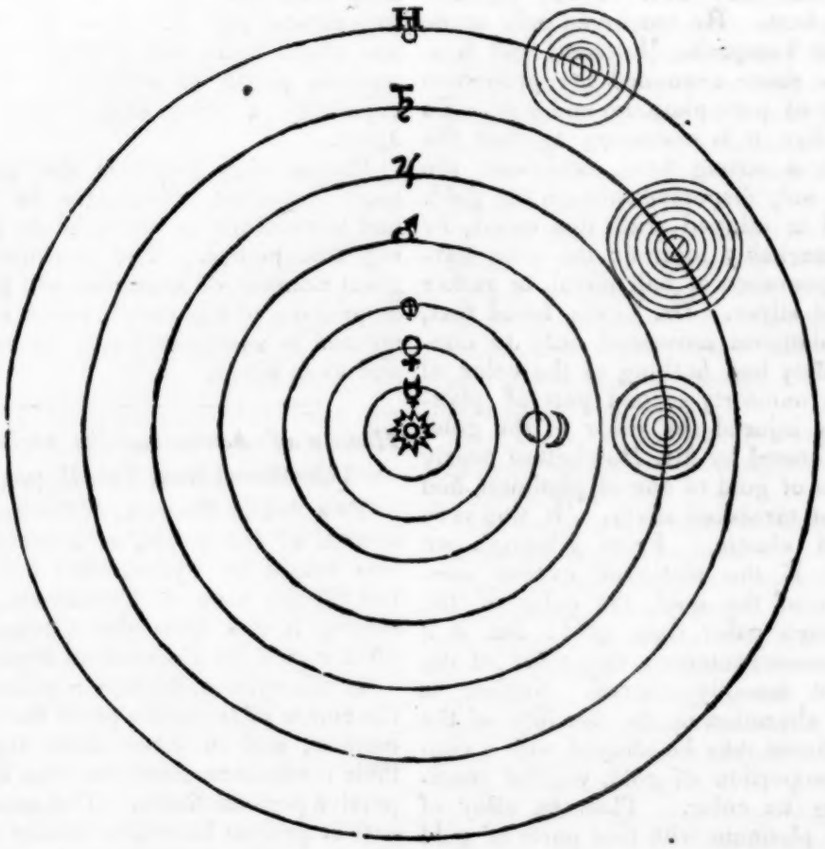
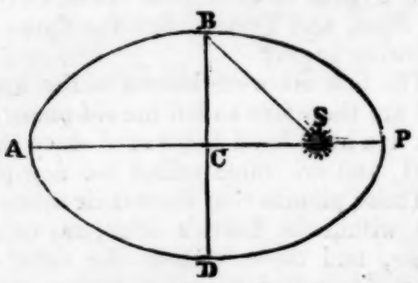
* From the labors of Sir Isaac Newton to establish the system of Copernicus, it is sometimes called the *Newtonian* system.

† This figure represents the order in which these planets move round the Sun; but the circles, which represent the respective orbits, do not show the proportioned distance of each planet from the Sun. To do this accurately would require a very large figure.



Sun, and the Secondaries round their Primaries, are not exactly circles, but Ellipses or Ovals.*

Now though this be the form of the orbit



which the planet describes, yet the place of the Sun is not in the centre of the orbit, but in one of the Foci, as at S.

When the planet is at P, it is then nearest the Sun, and is said to be in its Perihelion. In moving from P, its distance from the Sun gradually increases till it reaches the opposite point A, when it is at its greatest distance from the Sun, and is then said to be in its Aphelion. When it arrives at the points B and D, it is said to be at its Mean Distance. The straight line A P, which joins the perihelion and aphelion, is called the line of the Apsides, and sometimes the greater axis or the transverse axis of the orbit. The line B D, joining the points of *mean* distance, is called the conjugate or lesser axis: S B or S D, the planet's mean distance from the Sun; S C or F C, the eccentricity of the orbit, or the distance of the Sun from its centre; S the lower Focus, or that in which the Sun is placed; F the higher Focus; P the *lower Apsis*, and A the *higher Apsis*. Though the Primary Planets have all nearly the same common focus in which the Sun is situated, yet they have not all the same degree of ellipticity. Most of them deviate but little from the circular form, and none of them so much as the last figure. The orbits of the different planets do not all lie in the same plane, as they appear to do, when represented on paper.

If the Earth's orbit be supposed to be a thin solid plane, and to be extended in every direction, it will mark out a line in the starry heavens, which is called the *Ecliptic*, and the plane itself is called the *Plane of the Ecliptic*. The orbits of all the other planets

* If the two ends of a thread be tied together and thrown loosely over two pins stuck in a table, as S and F, (figure above,) and if the thread be moderately stretched by the point of a pen or black lead pencil, and carried round the pins by an even motion and slight pressure of the hand, an ellipse or oval will be described; the points A and P, where the pins were fixed, are called the foci, or focuses of the ellipse. The figure described will be the more elliptical the tighter the thread is to the pins in the foci.

lie in planes different from this plane; but the one half of each orbit rises above it, and the other falls below it,* consequently the orbit of each planet crosses the ecliptic in two opposite points, which are called the planet's *Nodes*. These nodes are all in different parts of the Ecliptic, and therefore if the planetary tracks remained visible in the heavens, they would in some measure resemble the different ruts of waggon wheels crossing each other in various parts, but never going far asunder. That *node* or intersection where the orbit ascends above the ecliptic is called the *ascending node*, and the other, which is directly opposite to it, is called the *descending node*.

While the primary planets are performing their revolutions round the Sun, and the secondaries round their primary planets, they have all a motion from west to east round an imaginary line passing through their centres, called their axes. The axis of some of the planets is much more inclined to the axis of its orbit than others, and on this depends the change of seasons in the planet;† for the more the axis of any planet is inclined to the axis of its orbit, the greater will be the variety of its seasons.‡ The extremities of the axis of any planet are called its Poles. That which points towards the northern part of the heavens is called the North Pole, and the other pointing towards the southern part is called the South Pole.

As the Earth turns round its axis in 24 hours, the heavens will appear to make a complete revolution in that time: and to a spectator on any of the other planets, this revolution will seem to be performed in the time which this planet takes to perform a revolution on its axis, which is called the length of the planet's day.

As it is necessary to have some method by which the position of any celestial body may be determined at any time, or its distance from some known point, astronomers have fixed on the Ecliptic or Earth's orbit for this purpose, as well as for reckoning from it the inclination of the planetary orbits. The line of the Equinoxes, or that line in which the Earth's equator, when extended to the heavens, cuts the Ecliptic (being always in the plane of the Ecliptic) must mark out two points of that line traced among the stars; and from one of these points astronomers reckon the distances on the ecliptic. This point is called the *vernal* Equinox, because the Sun appears in it about the middle of Spring or the 20th of March; its opposite is called the *autumnal* Equinox, the Sun being in it about the middle of Autumn, or the 23d of September.

The Ecliptic is supposed to be divided into twelve equal parts, called signs, of 30 degrees each. Their names and characters are the following:

♈ Aries,	♎ Libra,
♉ Taurus,	♏ Scorpio,
♊ Gemini,	♐ Saggittarius,
♋ Cancer,	♑ Capricornus,
♌ Leo,	♒ Aquarius,
♍ Virgo,	♓ Pisces.

The *Longitude* of all the heavenly bodies is reckoned eastward on the ecliptic from the vernal equinox (where the sign Aries begins) quite round the heavens.

The *Latitude* of any celestial body is reckoned from the ecliptic, north and south; but its declination is counted from the equinoctial, in a similar manner.

The *Right Ascension* of any celestial body is reckoned on the *equinoctial* from the vernal equinox, or the first point of Aries, eastward quite round the heavens.

Instead of the vernal equinox, astronomers sometimes find it convenient to count the distance of a planet from its aphelion. This distance is called the true anomaly of the planet.

Of the Sun.—The Sun is the largest body yet known in the universe. His diameter is 887,693 English miles; his circumference 2,800,000; and his bulk is above 1,400,000 times greater than the Earth. Although the Sun be the fixed centre of the universe, he has been discovered to have a motion round his axis in 25 days 10 hours, and another round the centre of gravity of the planetary motions. The motion round his axis was discovered by Galileo in the year 1611.

When the Sun is examined with a telescope of a tolerable magnifying power, and a piece of dark glass interposed to prevent his rays from hurting the eye, a number of dark spots, of various forms and magnitudes, are frequently perceived on his disc. These spots are sometimes so very large as to be perceptible with the naked eye. The nature and formation of the solar spots have been the subject of much speculation and conjecture.

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* The angle which each orbit makes with the plane of the ecliptic is called the inclination of the orbit. The orbit of Mercury is inclined 7° to the plane of the ecliptic; Venus, 3° 23′; Mars, 1° 51″; Jupiter, 1° 19″; Saturn, 2° 30′; Uranus, 0° 46½′; Ceres, 10° 37′; Pallas, 34° 50′; Juno, 21°; and Vesta, 7° 9′. The orbits of all the *old* planets are included in the Zodiac, which is a belt or zone in the Heavens, extending about 8° on each side of the ecliptic: but the orbits of the *new* planets are without the zodiac.

† The axis of the earth is inclined 23° 28′ to the axis of its orbit, which is the cause of the different lengths of the days, and variety of the seasons.

‡ The axis of the orbit of any planet is a straight line, perpendicular or at right angles to the orbit.

Some astronomers have affirmed that the Sun is an opaque body, mountainous and uneven like the Earth, and covered all over with a fiery and luminous fluid: that this fluid ebbs and flows after the manner of our tides, so as sometimes to leave uncovered the tops of rocks or hills, which appear like black spots, and that the nebulosities about them are caused by a kind of froth. Others have imagined that the fluid which sends us so much light and heat contains a nucleus or solid globe, wherein are several volcanoes, which, like Ætna or Vesuvius, from time to time, cast up quantities of bituminous matter to the surface of the Sun, and form those spots that are perceptible on his disc; and that this matter is gradually consumed by the luminous fluid, and then the spots disappear for a time, but are seen to rise again in the same places when those volcanoes cast up new matter. A third opinion is that the Sun consists of a fiery luminous fluid, wherein are immersed several opaque bodies of irregular shapes; and that these bodies, by the rapid motion of the Sun, are sometimes buoyed or raised up to the surface, where they form the appearance of spots, which seem to change their shapes according as different sides of them are exposed to our view. A fourth opinion is, that the Sun consists of a fluid in continual agitation; that, by the rapid motion of this fluid, some parts, more gross than the rest, are carried up to the surface of the luminary, like the scum of melted metal rising up to the top in a furnace; and that these scums, as they are differently agitated by the motion of the fluid, form themselves into those spots that are visible on the solar disc.

Dr. Herschel supposes the Sun an opaque body like the planets, surrounded by an atmosphere of a phosphoric nature, with a number of luminous clouds floating on it; and that the dark nucleus of the spots are occasioned by the opaque body of the Sun appearing through openings in his atmosphere.

The late Dr. Wilson, of Glasgow, has advanced a new opinion respecting the solar spots. He supposes, with great appearance of truth, that they are depressions rather than elevations; and that the dark nucleus of every spot is the opaque body of the Sun seen through an opening in the luminous atmosphere with which he is surrounded.

Amidst all these conjectures, we are still left in uncertainty: for there appears little in any of them to entitle it to a superiority over the other. In one particular they all agree: namely, that the Sun is either composed of, or surrounded by, some very powerful heating substance; but what that substance is, or how it is maintained, they are all at a loss to determine. Many experiments have been made, both in this country and on the continent, to determine the heat of the Sun, or the *intensity* of his rays, when concentrated in the focus of a lens, or by reflecting mirrors. Among these may be mentioned the experiments made by Dr. Harris and Dr. Desaguliers, with a mirror constructed by Mr. Vilette. It was 3 feet 11 inches in diameter, and its focal distance was 3 feet 2 inches. A fossil shell was calcined by it in 7 seconds; copper ore vitrified in 8 seconds; iron ore melted in 24 seconds; talc began to calcine in 40 seconds; a great fish's tooth melted in 32½ seconds; a silver sixpence melted in 7½ seconds; a copper halfpenny melted in 20 seconds; tin melted in 3 seconds; cast iron in 16 seconds; slate melted in 3 seconds; bone was calcined in 4 seconds. So powerful are the Sun's rays when condensed by burning glasses, that it is said Archimedes set fire to the Roman fleet at the siege of Syracuse by a combination of these glasses; and Buffon, in the year 1747, constructed a reflecting mirror of 168 plane glasses, moveable on hinges, with which he set wood on fire at the distance of 150 feet, and melted lead at 145 feet.

On Magnets. By Geo. Clark. To the Editor of the Mechanics' Magazine.

Sir,—Having seen in a London periodical (the Lancet) an account of the wonderful cures at St. Bartholomew's Hospital, by Drs. Kyle and Blundell's newly discovered powerful magnets, I have been induced to make one from a model furnished me by a gentleman well acquainted with them. It has been tried by a medical gentleman in this city, on a lady much afflicted with rheumatic pains, and the success exceeded his most sanguine expectation. The magnet attracts the pain from the various parts of the body to the extremities; and from thence draws the pain away. I make this communication through your valuable magazine in hopes that others of the faculty may prove by experiments the great utility of this most interesting discovery, and thereby remove any doubt that may be entertained on the subject.

I am, sir, your obedient servant,

Geo. Clark,

136 Spring street, New-York.

January 7, 1834.

New Plaster Bed.—An inexhaustible bed of superior gypsum or plaster has been discovered on the Cascadilla, near the village of Ithaca, and proves equal to that from Nova Scotia.

INTRODUCTORY ADDRESS

Delivered before the Mechanics' Institute of the City of New-York, November 27, 1833,

by GULIAN C. VERPLANCK.

Several years ago, in conversation with a very ingenious and well-informed friend, now deceased, I was much struck by a transient observation of his. "In spite," said he, "of man's boasted intellect, he is as much indebted for his present state in civilized life, to the hand as to the head. Suppose," proceeded he, "that the human arm had terminated in a hoof or a claw, instead of a hand, what would have been the present state of society, and how far would mere intellect have carried us?"

I do not know whether this idea was original with my friend or not, although I have never since heard it or met with it in books; and as he did not follow it out any further, I cannot say what were the particular consequences he meant to infer from it. Let us for a moment take up the supposition and follow it out for ourselves. Let us suppose that all the other original as well as secondary causes, which have operated upon the human race, to bring civilized society to its present state of art, power, knowledge, refinement, and wide-spread comfort and luxury, to have remained as nearly as possible the same. Let us imagine the reason of man to have been as powerful, his curiosity as active, his talent, courage, energy, enterprize, equal, nay, if you will, superior to that which he now possesses and exerts. But in place of his hand, that exquisite and wonderful piece of mechanism, so beautiful in its contrivance, so perfect in its construction, so infinite in its uses, obeying the mind's impulse with an accuracy and rapidity which the mind itself cannot comprehend or follow—in place of that he has the paw of a wild beast. Under such circumstances, unquestionably, some form of society, of government, and of social order, might exist. The human mind might slowly observe and compare many of the truths of reason and the laws of nature. The first principles of mathematics, depending as they do upon pure reason, might possibly have been discovered, and the science of numbers and figure and measure developed in theory by individuals, to no inconsiderable extent. In a race of men so formed, there might possibly be poets and orators, whose fancy or eloquence might have rivalled or resembled those of the great names of the world's early history. There might, and there doubtless would, have been the frequent exertion of brute valor; and there probably would have been sometimes added that application of mind to courage, which makes of the soldier a hero, a leader, a conqueror.

But here the force of mere mind, in such a world as ours, must have stopped. Without the mechanical assistance of the hand, most of the discoveries and improvements of each generation must have died with them, and left no preparatory stock of knowledge to the next, for the want of the art of writing. But this, however great it may seem in itself, is but the most inconsiderable of the privations to which man would be subject. "Man," says Franklin, "is a tool-making animal," and without the hand, where would be the tools of agriculture—the plough, the spade, and the waggon? where the builder's skill, and the houses which now shelter happy families, in place of the cave and the forest? where the boat, the sail, the ship, which connect nations together, and make the wealth and the wisdom of each portion of our race in some degree the property of all? As we proceed in this analysis, we may thus trace back the comfort, the happiness, the safety, the splendor, nay, the very affections and virtues of social and civilized life, to the industry of the hand. Still, all this is the fruit of the labor of the hand guided by intelligence. It is the toil of the hand directed by experience, strengthened by knowledge gained by the past experiment, by the observation of nature, and by the application of reason to that experience and observation. This it is that constitutes that enlightened labor to which society owes its elevation and its happiness. This it was that

——"roused man from his miserable sloth,
His faculties unfolded, pointed out
Where lavish Nature the directing hand
Of art demanded, showed him how to raise
His feeble force by the mechanic powers,
To dig the mineral from the vaulted earth,
On what to turn the piercing rage of fire,
On what the torrent and the gathered blast
Gave the tall, ancient forest to his axe,
Taught him to chip the wood and hew the stone,

Till by degrees the finished fabric rose;
Tore from his limbs the blood polluted fur,
And wrapt him in the woolly vestment warm;
Nor stopped at barren, bare necessity,
But still advancing bolder led him on,
To pomp, to pleasure, elegance, and grace,
And breathing high ambition in his soul,
Let science, wisdom, glory, in his view,
And bade him be the lord of all below."*

Such, in the language, but without the exaggeration of poetry, are the magnificent results of intelligent industry, of the hand executing what the mind has devised or discovered; either of them without the other being powerless, to any greatly useful end. The mind without the hand must be compelled to waste its force upon barren speculation, or to amuse itself with the fleeting visions of fancy. The hand without the guiding mind is bloody and dangerous, quick to injury, slow and awkward in any work of peace. Let them act together in intelligent unison, and then the whole man and the whole frame of society will move together in cheerful activity, right onwards to their highest possible perfection and happiness. It is the boast of our own country and times, and civil condition, that they are all auspicious to this union and the attainment of these ends. To co-operate to the best of his ability in securing and hastening forward this excellent and beneficent effect, and especially to make its blessings more immediately felt by those around and about him, is at once the duty of every good citizen and his most exalted privilege.

It is with such motives and views that you, fellow-citizens, have founded the Mechanics' Institute of the City of New-York. Its primary object you have stated, in your constitution, to be "the instruction of mechanics and others in popular and useful science, and its application to the arts and manufactures, by means of lectures, apparatus, models of machinery, a museum, and library."

In discharging the grateful and honorable duty which you have confided to me, of opening the course of scientific lectures arranged for the present season, perhaps I cannot better employ the limits of an introductory lecture, too circumscribed for the particular elucidation of any single prominent branch of scientific inquiry, than by considering a few of the more important advantages which may justly be expected to flow from instruction of the kind proposed by your institution.

Let me invite your attention, first, to the consideration of the probable beneficial effect of the diffusion of scientific knowledge, amongst those practically and habitually employed in the mechanic and manufacturing arts, as it is likely to operate upon the improvement and advancement of the arts and sciences themselves. This is a view of the subject which probably did not occupy the foreground in the minds of the founders of the Institute; but I place it first, because it first occurred to my own thoughts, and because, too, if not the very first in importance among the many uses of such institutions as this, it is scarcely secondary to any other.

Perhaps there is no better definition of Science, than that it is knowledge acquired by the thoughts and the experience of many, and so methodically arranged as to be comprehended by any one. That which exhibits the truth, reasoned out by the mind from its own intuitive perceptions, and which relates not merely to that which is, but to that which *must* be, (such as the deductions of mathematics,) constitutes abstract science.

Physical science is the methodized and therefore simplified knowledge of the order of nature, so far as hitherto observed. This consists mainly in the classification, under general rules and names, of multitudes of observations and experiments. It arranges and generalizes the observations of all ages, made by those who, with eager eyes and attentive minds, have read the great book of Nature, which she opens of her own accord to all men, and the experiments, that by new and bold combinations of agents, or powers that do not ordinarily appear together, have questioned Nature herself, and forced her to reveal the secret rules and methods of her mighty operations. It is the business of the true teacher of useful science to lay all this before his pupils, clearly, briefly, and methodically, thus following out and applying that beautiful and benevolent fundamental law of the Author of all being and of all wisdom, who, governing all things by vast and comprehensive rules, includes millions of apparently jarring phenomena under the operation of some single cause, and has thus made a kind provision whereby the limited mind of man may grasp and turn to its own uses the laws that sway the whole creation.

The theory of science, then, is the exposition of known facts, arranged in classes and

* Thomson.

expressed in words. Let then this general and preparatory acquaintance with the ascertained laws of nature be widely spread amongst those who are constantly and habitually engaged in the various operations of the useful arts, and what will be the probable consequence? Instead of a comparatively few observers, most of whom see nature "through the spectacles of books," or at best on the limited scale of the laboratory or the lecture room, we have at once hundreds of men well grounded in the principles of chemistry, mechanics, and general physical science, perpetually observing, watching, comparing, applying, the working of those principles on the largest scale, and under some peculiar advantages, which the man of mere speculative science can rarely enjoy. For instance, all who have ever turned their attention to mechanical invention know how often and how signally the most ingenious conceptions, succeeding admirably in the model, are frustrated and found worthless when applied to practice on the scale necessary for any useful purpose. However valuable the model may be as an auxiliary, nothing but actual experience can teach the operation of friction, of gravity, of the nature of materials, of the varying proportion of weight and strength in relation to an increased scale of size, and numerous other circumstances which would require a lecture to detail.* But the knowledge of all this is precisely what constitutes the difference between the accomplished speculative projector and the successful practical machinist; and as all this is every hour before the eyes of the actual mechanic, it surely must prove a great thing for the improvement of mechanical skill and invention, to have this observation assisted and enlightened by sound theory, or, in other words, by a clear and distinct apprehension of what has already been invented or discovered.

In visiting our national patent office, and conversing with the officers of the establishment, it becomes a common subject of remark, how prodigious a waste of ingenuity, in various ways, and particularly in mechanical contrivance, takes place annually in this country, for the want of a more general knowledge of the actual state of improvement in the several departments of invention. Hundreds of useful or ingenious machines have been thus re-invented, doubtless with no little loss of that intellectual labor, which, if it had been applied in improving or building upon what was already known, might have opened to society new sources of comfort, of pleasure, or of power.

The advantages of experience and observation on a large scale, are, by no means, peculiar to mechanical ingenuity. Indeed, I meant to draw from it simply an example or illustration of a truth common to all the mechanic and manufacturing arts. It is peculiarly true with regard to the chemistry of the arts. It has been remarked by the most successful chemists of our day, that some of the most important manifestations of the laws of chemical action could hardly have been discovered in the course of any of the experiments of the chemical laboratory, however skilful or costly. In order to manifest themselves to observation, they require the action of large masses or quantities together, perhaps that of the elements upon them, or of a considerable lapse of time. In fact, the very foundation of modern chemistry, or at least of that branch of it termed Pneumatic Chemistry, was laid in a brewery. There had been no lack of ingenuity, no sparing of labor or expense, no flagging of zeal or curiosity among the old chemists. But the larger and more striking field of observation and combination afforded to Dr. Priestley, by the vats and gases of his neighbor the brewer, opened a new world to inquiry. From the thick vapors of the brewhouse, like one of the gigantic genii of Arabian romance, arose that mighty science which has given to enlightened art a more than magical sway, enabling her to clothe her productions with vivid beauty, to dispense amongst all those fabrics which were once reserved for kings and princes, to chase away disease, and to arm man with a strength such as ancient poets never dreamt of in their wildest tales of heroes, giants, and demi-gods.

Will it not, then, promise much for the still further and more rapid advancement of knowledge and art, if all those immense processes, combinations, unions, affinities, conversions, formations, decompositions, which are incessantly going on in the brewery, the dye-house, the distillery, the manufactory of drugs, paints, metals, glass, porcelain—in short, in all the establishments of refined and ingenious art; I say, to have all these watched, tested, analyzed, applied, separated from whatever may impede their action, or united to whatever may add to it—and this done by men skilled in their particular vocations, and, moreover, able to call in the aid of science to explain difficulties or direct observation?

It is wonderful how the elements of the most precious knowledge are spread around us

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* See them well explained in an ingenious paper, by Mr. Sang, "on the relation between a machine and its model," printed in Silliman's Journal, Vol. xxii. No. 2; also, in this Magazine. Vol. i. No. 6, p. 302.

—how to the curious and instructed observer every thing is full and rich with the means of benefitting the human race. The slightest accession to our knowledge of nature, or our command over it, is sure ultimately to connect itself with some other truth, or to unfold its own powers or relations, and thus to lead on to some practical benefit, which the boldest conjecture could never have anticipated. The ignorant and the idle suffer all such opportunities to pass by them as the vagrant breeze. But such will surely not be the case with industrious men, prepared by general science (as it is the object of this institution to prepare them) to turn those occasions to the best account. In so saying, I do not speak from hope or conjecture, or theory, or the desire of stimulating your zeal by flattering words. I argue from experience. I draw my anticipation of what may be, from the actual history of what has been. Let me give you the evidence of this by some few examples selected out of many hundreds. Take for instance the history of one of the most recent and precious gifts which chemistry has made to medicine.

A few years ago a soap manufacturer of Paris, M. Courtois, remarked that the residuum of his ley, when exhausted of the alkali, produced a corrosion of his copper boilers, which struck him as deserving special inquiry. "He put it," says Mr. Herschell, "into the hands of a scientific chemist for analysis, and the result was the discovery of one of the most singular and important chemical elements, *iodine*. The properties of this, being studied, were found to occur most appositely in illustration and support of a variety of new, curious, and instructive views then gaining ground in chemistry, and thus exercised a marked influence over the whole body of that science. Curiosity was excited; the origin of the new substance was traced to the sea plants, from whose ashes the principal ingredient of soap is obtained, and ultimately to the sea-water itself. It was thence hunted through nature, discovered in salt mines and springs, and pursued into all bodies which have a marine origin; among the rest into sponge. A medical practitioner (Dr. Coindet, a Swiss physician,) then called to mind a reputed remedy for the cure of one of the most grievous and unsightly disorders to which the human species is subject—the *goitre*,—which infests the inhabitants of mountainous districts to an extent which, in this favored land, we have happily no experience of, and which was said to have been cured by the ashes of burnt sponge. Led by this indication, he tried the effect of iodine on that complaint, and the result established the extraordinary fact, that this singular substance, taken as a medicine, acts with the utmost promptitude and energy on goitre, dissipating the largest and most inveterate in a short time, and acting (of course with occasional failures, like all other medicines,) as a specific or natural antagonist against that odious deformity."

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Let us cross the channel to Great Britain for some further examples, and learn from what has been done there by mechanical, united to scientific skill, what we may reasonably hope to see done among ourselves.

It were idle to waste words in showing how much of the present prosperity, wealth, intelligence, and means of enjoyment, in the civilized world, depends upon the art of navigation—and how much the perfection of that art is connected with the accuracy and advance of astronomy—and, again, how that science depends upon the excellence of its great instrument, the telescope. The telescope, in its earlier stages of invention, had received all the improvement that could then be furnished by the genius of the great Galileo, the father of modern science, and by the super-human philosophical sagacity of Sir Isaac Newton, as well as of their disciples and followers, the most learned and ingenious men of Europe, such as the English Hooke, the Dutch Huygens, and the German Euler.

The product of these labors was indeed an admirable proof of the power of human invention; yet it was accompanied with imperfections, especially in the refracting telescope, that seemed insuperable. Your lecturer, when explaining the doctrines of optics, will state to you, more fully and clearly than can now be done, the nature and cause of this

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The incidental mention of the ultimate advantages derived by the art of navigation from the labors of Dollond, suggests to my mind another illustration, and recalls the name of JOHN SMEATON. He was by regular trade a philosophical instrument maker; but his active mind had taken a broad range of rational curiosity and employment, embracing almost every thing in science or art that could throw light on mechanical contrivance. His inventions of this sort were very numerous and ingenious, but his solid fame rests chiefly upon the erection of the Eddystone Lighthouse. Its site was one of the utmost consequence to the naval and commercial marine of Great Britain, and, indeed, of the world. As it was to be placed on a reef of rocks, far from the main land, and exposed to the whole force of the waves of the Atlantic, the building of a durable edifice there had baffled the skill of the ablest architects. At that period, about the middle of the last century, that branch of marine construction which relates to piers, moles, artificial harbors, breakwaters, &c., was far from that scientific developement it has since received, and which it in no small degree owes to Smeaton himself. The commissioners for re-building the lighthouse, aware of the difficulties they had to encounter, reported that this was not an undertaking for a mere architect, however skilful, but required the talent of some one eminent for general mechanical skill and contrivance. Smeaton was selected. His plan was wholly original, having been suggested immediately by the consideration of the means used by nature to give durability to her works, and taking the model of strength and resistance to the elements which she had given in the trunk of the oak.* The execution corresponded with the boldness and perfection of the first conception. There are few narratives of more intense interest or varied instruction than his own account of this great work, which is among my earliest and most vivid recollections of this sort of reading. I will not attempt to mar it by a meagre abstract. It is enough to say that this noble effort of mechanical genius, thus grafted upon and made part of the rocky bottom of the sea, and resisting the immense might of the ocean, which it faces, has never been surpassed or improved upon, but has been the model or guide of numerous subsequent works of marine construction of great excellence and unbounded utility.

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But, in the eye of sober reason, how poor and how vain are these monuments of pride, of power, of glory, and even of genius, when compared to the solitary sea-girt unadorned Atlantic tower, which perpetuates the name, the talent, and the unambitious labors of John Smeaton! The glories of the conquerors have vanished like the morning mist. Their conquests and their empires have crumbled into dust; but the Eddystone tower stands firm amidst the tempest and the uproar of the ocean; and there, and wherever else its form is imitated or its principles applied, as on our coasts and on the shores of our western lakes, it throws its broad light across the storm and the gloom, giving safety to the mariner, and guiding that commerce which, making the natural riches of every climate the common property of all, is surely destined to bind together the whole family of man in the mutual and willing interchange of art and learning, and science, and morals, and freedom.

I might continue my illustrations from the history of useful science to an extent far beyond the limits that would be proper on this occasion. The names and lives of our own distinguished benefactors of mankind, Franklin and Rittenhouse, and Whitney, and Fulton, and Perkins, press upon my memory. Again, the history of the watch and clock, from their early invention to their present admirable state of perfection in the astronomical clock and the marine chronometer, as successively improved by men educated in the practical art and able to apply the helps of science, would alone afford the materials for a lecture.

The history of printing offers another tempting field of collateral illustration. I might show you how numerous and how precious are the contributions, that have been made by a succession of learned printers, to literature, philosophy, and those principles of tolerance and freedom, which it is the sacred office of the press to perpetuate and diffuse. I might tell of the Italian Aldus and his sons, of Henry Stephens of Paris and his learned family, of the Dutch Elzevirs, the English Bowyer, the Scotch Foulis and Duncan, and surely could not forget the noblest name of them all, our own Franklin. It is from the influence of these men, and such as these, that the printing office has become, to use one of its own phrases, the *Chapel* of Liberty, where is her living presence, and where are reared the altars upon which are daily kindled the clear and bright lights of instruction for the illumination of mankind. There the goddess treasures up her arms, her ægis, and her lightnings. There is she worshipped by an assiduous, an intelligent, an ardent, and a faithful priesthood.

I must also reluctantly refrain from detailing the studies, inventions, and improvements of the potter, Josiah Wedgewood. His chemical and geological acquirements, applied to the experience of his Staffordshire pottery, have filled the houses of all classes with those cheap, cleanly, and elegant luxuries of china and finer earthenware, such as before his days princes alone could purchase; whilst his pure taste and acquaintance with antiquity have imparted to the ordinary productions of the potter's mould and lathe, the grace and beauty of the most costly works of ancient art.

I content myself with barely mentioning these points of illustration, leaving them to be followed out by your own reading or recollection. But from among the names that thus crowd upon me, let me adduce one more bright example, which I select chiefly because it is most intimately and gloriously connected with that application of science to which our own country, and, I may add, our own state and city, are most largely and peculiarly indebted.

It was about this season of the year, just seventy years ago, that the instrument maker, employed by the University of Glasgow, received from the Professor of Natural Philosophy, in that ancient seminary of learning, a broken model of the steam engine as then used, to be put in order for his lectures. It was the simple and very imperfect machine of Newcomen, the best form of the steam engine that had then appeared, and which had been found rather useful as a somewhat economical substitute for the labor of men or horses. But no one had yet viewed the steam engine as the means of a new creation of force, whereby the winds and the waves could be breasted and subdued, the weight of mountains raised, or the most delicate manipulations of the human hand imitated and surpassed. An ordinary workman, after admiring the ingenuity of this imperfect machine, would have made the necessary repairs, sent it back to the lecture room, and the world would have gone on as usual. But it had fallen into the hands of James Watt, a young mechanic, of singular and various inventive sagacity, and of most patient and persevering ingenuity, who, in addition to much miscellaneous information and some mathematical acquirement, had been led by a liberal curiosity to master all that was then known of chemistry and theoretical natural philosophy in its broadest sense. He was struck with the latent capabilities of the agent used in the imperfect engine before him; and to develope these powers, he applied his mind, he tasked his invention, he called in the aid of all collateral science. The mode

and extent of his success have doubtless been heretofore explained to those of you not practically acquainted with the subject, and will I presume again form a part of this winter's course of instruction. I invite you now only to consider what was achieved by the labors of Watt. He was not merely the improver of the steam engine, but in fact, as to all that is admirable in its structure or vast in its utility, he has the clear right of being honored as its inventor. "It was by his invention," says an eloquent eulogist of his character and genius,* "that its action was so regulated as to make it capable of being applied to the finest and most delicate manufactures, and its power so increased as to set weight and solidity at defiance. By his admirable contrivances, it has become a thing stupendous alike for its force and its flexibility; for the prodigious power that it can exert, and the ease, precision, and ductility, with which it can be varied, distributed, and applied. The trunk of an elephant, which can pick up a pin or rend an oak, is as nothing to it. It can engrave a seal, or crush masses of obdurate metal like wax before it—draw out without breaking a thread as fine as gossamer, and lift a ship of the line, like a bauble, into the air. It can embroider muslin and forge anchors—cut steel into ribbons, and impel loaded vessels against the winds and waves."

But look around for yourselves—on our rivers and lakes—on the manufactures of Europe and America, piled up in our shops—on the railroads which traverse, or are just about to traverse, our continent—on the wealth, the power, the rapid interchange of commerce and intelligence produced by the modern steam engine,—and then let me remind you that all this is the fruit of the solitary labors and studies of a Glasgow work-shop, directed by an active, vigorous, daring, but most patient and persevering mind, which knew how to use well the knowledge that other wise or ingenious men had previously reasoned out or discovered. Much of this stupendous result Watt beheld with his own eyes, for he continued to apply and improve his invention for more than half a century. He lived to see the complete success of its application to navigation by our own Fulton, who, great as were his various merits and inventive resources, would have labored in vain had he been obliged to rely for the moving power of his machinery upon the feeble ancient engines of Savary or Newcomen. Watt died in 1819, full of years and honors.† How splendid a reward of well directed intellectual labor! What an animating excitement is the contemplation of it to the best aspirations of a bold and generous, but also of a wise, a useful, and a benevolent ambition!

I trust that I need adduce no further evidence to show of what infinite consequence it is to society, that the phenomena and the processes of nature and art should be constantly watched by well instructed eyes, and of what incalculable value the slightest new fact thus gathered, (as in the case of the chemical antidote to the disease of goitre,) may prove to the whole human family. Thus it is, that whether like Dollond, Smeaton, or Watt, you are yourselves the happy agents of spreading more widely the dominion of mind over matter, or whether you merely enrich human knowledge by some single additional fact, the use of which may at some future time be developed by others, you will in either case attain the generous wish so well and strongly expressed in the plain but expressive words of one of the reports of your Institute, and "will leave the world in a better state than you found it."

There is, I think, another and not less wholesome influence upon science, to be derived from its being made familiar to the thoughts of men, whose ordinary habits of life are exclusively practical.

It would be a poor affectation in me, were I to pretend to hold cheap the acquirements of the closet, and the researches and conclusions of retired and speculative philosophy. For in this class must be reckoned the wisdom of Newton, Leibnitz, Euler, Locke, Butler, the great lights of mathematical and physical and moral truth. But it must be confessed, that it is the uniform tendency of all purely speculative and scholastic science, to wander into visionary abstractions, to shroud itself in abstruse technicalities, and, above all, to substitute words of learned length, and rules or maxims of arbitrary authority, to simple and intelligible reason. Thus men of erudition and science often impose upon themselves as well as upon others. Now I can imagine no more effectual corrective to this tendency,

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* Mr. Jeffrey.

† Amongst these honors must be particularly noticed two sketches of his character: the one from the pen of Franci Jeffrey, the other from that of Walter Scott. In both of these, those eminent men have done honor to themselves as well as to the memory of their friend, by the warmth of feeling with which they have described his virtues and talents, his amazing stores of miscellaneous knowledge, and that unclouded amiable temper and unflagging benevolence which made this profound philosopher, this creator of power, this potent magician, whose machinery has changed the whole world, to be in private life one of the most delightful of companions, and the best and kindest of human beings.

than the bringing science to the test and the ordeal of the general mind, the applying to its doctrines the reason and the experience of society. Not that every man, nor any one man, can be capable of judging of the soundness or worth of all science; but that the aggregate good sense of the community is thus brought to bear upon the whole body of theory. Mysteries enough in physical and moral nature will still remain; but they will be known and confessed to be so from the present limited powers of the human mind. We shall not think we understand them, because we have good and well sounding words wherewith to conceal our ignorance. Two centuries ago all the wonders of nature were explained, or supposed to be so, by the mystical and imposing maxim that "Nature abhors a vacuum." Then came a theory of *vortices*, or little and great whirlpools pervading all creation, and these too accounted for every thing. We should have never found out that all this was a string of empty words and arbitrary assertion, if men had done nothing but write or talk on the subject. It was the air pump and the barometer, the crucible and the retort, the application of science to the wants of life, that silently refuted it all and substituted more solid knowledge. An excellent writer of our own day, (Mr. Herschell,) to whom I have been before indebted, has so well and strongly stated the truth which I wish to impress, that I should only dilute his sound and manly sense, were I to clothe his ideas in any other words than his own.

"Knowledge can neither be adequately cultivated nor adequately enjoyed by a few. It is not like food, destroyed by use; but rather augmented and perfected. It acquires, perhaps, not a greater certainty, but at least a confirmed authority and a probable duration by universal assent; and there is no body of knowledge so complete but that it may acquire accession, or so free from error but that it may receive correction by passing through many minds. Those who admire and love knowledge, for its own sake, ought to wish to see it made accessible to all, were it only that its elements may be the more thoroughly examined into, and more effectually developed in their consequences, and receive that ductility and plastic quality which the pressure of minds of all descriptions, constantly moulding them to their own purposes, can alone bestow. To this end it is necessary that science should be divested, as far as possible, of artificial difficulties, and stripped of all such technicalities as tend to place it in the light of a craft, or a mystery, inaccessible without a kind of apprenticeship. Science, of course, like every thing else, has its own peculiar terms; and these it would be unwise, were it even possible, to relinquish; but every thing that tends to clothe it with a strange and repulsive garb, and especially every thing that, to keep up an appearance of superiority in its professors over the rest of mankind, assumes an unnecessary garb of profundity and obscurity, should be sacrificed without mercy. Not to do this is to deliberately reject the light, which the natural unincumbered good sense of mankind is capable of throwing on every subject, even in the elucidation of principles. But where principles are to be applied to practical uses, it becomes absolutely necessary; as all men have then an interest in their being so familiarly understood that no mistakes need arise in their application."*

We may remark something analogous to this effect in our personal experience of the operations of our own minds. A man may have worked out in his head a new general rule in arithmetic, or he may plan a large building or scheme out in his mind, a machine in all its parts to his perfect satisfaction. Yet he cannot safely rely upon these mental abstractions, until he reduces them to an actual trial; of the rule, for instance, by working a question or problem with it, of the plan by laying it down on paper, or of the machine by essaying it in a model; in short, as the phrase is, he must see how it works. Then, there is always an even chance that he will find that his general ideas were, if not somewhat erroneous, at least imperfect, that he had overlooked or omitted something essential. But the putting the great body of men of experimental skill in possession of the principles of scientific theory, is precisely the doing, on a very extensive scale, what the individual does on a small one, in such cases as those just mentioned. This will show how the theory works. This tries and proves, or else limits and corrects, the general propositions of speculation, by comparing them with specific examples, and thus submitting them to the experience and common sense of mankind.

This salutary influence of general inquiry and knowledge is by no means limited to pure science. We may go much further. Mathematicians have said, and truly, that the spirit of geometrical reasoning is not limited in its application to mere geometry; but that the method, the clearness, the exactness, that distinguish mathematics, gradually communicate themselves to other studies, opinions and pursuits, so that at length their effect is felt even

* Discourse on the Study of Natural Philosophy, by I. F. W. Herschell.

among those who are ignorant of mathematics. Such, it seems to me, must also be the effect of sound and well digested knowledge, of any kind, upon the general habits of the mind, and ultimately upon all the great interests of society. It forms and strengthens a rectifying and methodizing power of the understanding, such as that for which James Watt and Benjamin Franklin were so eminently distinguished upon every subject that came under their examination. It induces the regular appetite for distinct reason, the desire of light and truth in all things. Now error and fraud love to hide themselves in a cloud of wordy generalities—to imitate mysterious difficulties—to magnify the importance of phrases, or terms, or usages, of ambiguous or of no meaning, though sanctioned by time, or by party, or by authority—in short, to protect themselves and impose upon others by means which, when at length honestly analyzed, turn out to be mere *humbug*. The word is a coarse one, and is branded by critics and dictionary makers as low. I believe it may be so. I can only wish that the thing itself received no more countenance among the great and learned than the word.

But real wisdom and legitimate science, however abstruse or difficult upon the first examination, whatever great and unsurmountable mysteries may be mixed with their certainty, yet dread not the public gaze. They ask no aid from delusion or from ignorance. They claim the light of day, and rejoice and expand themselves in the full flood of its noontide blaze.

Therefore it is, fellow-citizens, that the diffusion of real knowledge, and the universal habit of investigating scientific or moral truth, cannot but ultimately have a most purifying and exalting effect upon our political institutions, our jurisprudence and administration of justice, our civil and even municipal and local policy.

It is sufficient to have indicated these general views: you will yourselves judge of their correctness. I could not enlarge upon them without at least entering upon topics leading to controversial discussion.

I have not yet touched upon the influence of knowledge, such as that to which your institution invites the mechanics of this city, upon the operative and producing classes themselves, in improving the character, raising the thoughts, awakening sleeping talent, and thus qualifying this great and valuable body for the able, just, right, wise, and honorable discharge of all the duties of men, of citizens, of freemen, and of patriots. This is alone and in itself a theme full of interest—full of excitement. As it was doubtless a leading motive in founding this Institution, I had intended to make it the principal subject of this opening lecture. But I found that it was so familiar to the thoughts—I may rather say, to the hearts—of your members, and it had already been so strongly and well urged in the addresses and reports of your committees, that I could add very little indeed to the deep conviction and impression that had already been made. This gives the promise of a noble harvest of usefulness from the seed which may be sown here. But it was for these reasons that I have rather chosen to attempt exciting your minds to the holy ambition of "leaving the world better than you found it," by pointing out what experience has proved that you can do for the cause of science and reason, than to repeat what you already know and feel, and to tell you what science and reason can do for you.

Yet if exhortation on this head were needed, you would find in the history of our own country a lesson to this effect, far more instructive, far more animating, far more impressive, than any that mere rhetoric such as mine could give—than even the highest eloquence could teach. What is the history of our war of Independence, but the story of the struggles of a poor and a peaceful, but a generally educated, well informed people, against cultivated talent, abundant wealth, and disciplined valor? Then, in the glowing language of one of our own bards,*

> Then war became the peasant's joy; her drum
> His merriest music, and her field of death
> His couch of happy dreams
> After life's harvest home.
>
> He battles, heart and arm, his own blue sky
> Above him, and his own green land around;
> Land of his father's grave.
> His blessing and his prayers!
>
> Land, where he learnt to lisp a mother's name,
> The first beloved on earth, the last forgot—
> Land of his frolic youth –
> Land of his bridal eve!

* Halleck. Field of the Grounded Arms.

Land of his children! Vain your columned strength,
Invaders! vain your battle's steel and fire!
Choose ye the morrow's doom,
A prison or a grave.

Such were Saratoga's victors—such the brave men whose blood earned our liberties. Foremost among these was the blacksmith of Rhode Island, NATHANIEL GREENE: he whom Hamilton, whilst he honored Washington as "the first *man* of the country," did not hesitate to style "the first soldier of the revolution."* He was a man not more remarkable for his genius and patriotism, than for his insatiable thirst for knowledge, and the eagerness with which even in early youth he seized upon every opportunity of mental improvement. There also was the bookbinder KNOX, and from among the mechanics of New-York came forth our WILLET,† "the bravest of the brave."

Abroad, our interests were watched over, and our national dignity represented, by the printer FRANKLIN, who, amidst the varied avocations of a busy life, had made himself one of the most accomplished men of the times, and after attaining the highest honors of scientific fame, in his venerable and illustrious old age brought all that learning, science, and fame, to the service of liberty.

Foremost in our councils at home, and enrolled among the immortal names of the committee of five who prepared and reported the Declaration of Independence, was the shoemaker, ROGER SHERMAN, a man self-educated and self-raised. He was one who by mere intellect and knowledge commanded the confidence of the wise and swayed the opinions of the multitude, for he had not the gifts of external show, or "the loud and rattling tongue of saucy and audacious eloquence." As an eloquent colleague of his in the senate and on the bench of justice‡ once described him to be—"he was a slow-spoken and almost tongue-tied man, but his head was as clear as light."

There were other names like these which I cannot now pause to recapitulate. Our more recent history is also full of instances of the most honorable offices of society honorably discharged by men who had enjoyed no higher early advantages than those I have named, but who had used well what they did enjoy.

But I fear to speak of the occurrences or the men of our own days, lest I should seem to play the flatterer. Still I cannot forbear from paying a passing tribute to the memory of a townsman and a friend. It is but a few days ago that the wealth, talent, and public station of this city were assembled to pay honor to the brave and excellent Commodore Chauncey. Few men could better deserve such honors, either by public service or private worth; but all of us who recollected the events of the struggle for naval superiority on the lakes during the late war with Great Britain, could not help calling to mind that the courage, seamanship, and ability of Chauncey would have been exerted in vain, had they not been seconded by the skill, the enterprize, the science, the power of combination, and the ready and inexhaustible resources of his ship-builder, HENRY ECKFORD.

But, fellow-citizens, I must not detain you any longer. I have but to say, that in the examples I have brought before you, you have the earnest, the pledge, the proof of what is in your power to achieve, of what you owe to yourselves and to your country. The ardor for improvement, the thirst for knowledge manifested by the mechanics of this and others of our cities, are gratifying indeed. As they spring from generous motives, as they overshadow and destroy meaner propensities and poorer desires, they afford of themselves no barren subject of gratification to the patriot, the philosopher, and the philanthropist. But they derive a tenfold interest and value from the greater results which they foretell, and the more glorious future they appear to usher in.

Even so, the mild and balmy spring, whilst it gladdens the eye with the young grain, the tender grass, and the white and purple blossoms of the orchard, gives to the mind the cheering promise of the life-sustaining corn, the delicious fruit, and all the riches, the joys, and beauties of serene, bright, and abundant autumn.

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* I state this opinion and language of General Hamilton, in relation to the military character of Greene, on the authority of the late Colonel Marinus Willet, (who cordially concurred in the same opinion,) as used by General Hamilton in conversation at a meeting of the Society of Cincinnati, shortly after the death of Greene.

† Colonel Marinus Willet, afterwards Mayor of New-York.

‡ The late William S. Johnson, of Connecticut.

On the Microscope—Method of Constructing, &c. [From Partington's British Cyclopædia.]

The history of this instrument is veiled in considerable obscurity, and among the moderns the discovery of the microscope has been claimed by several individuals. The ancients appear to have been acquainted with it in one of its forms; for Seneca says, "Letters, though minute and obscure, appear larger and clearer through a glass bubble filled with water." In the middle ages this knowledge was lost. The invention of the modern instrument is attributed by the celebrated Dutch mathematician, Huygens, to a countryman of his, named Drebell, who constructed them about 1621, or 31 years after the invention of the telescope. Borelli attributes it to Jansen, the reputed contriver of the telescope; Viviani to Galileo. The first compound microscope, consisting of two double convex lenses, seems to have been made by F. Fontana, a Neapolitan, who dates his invention from the year 1618.

The numerous forms of microscopes may be included under the heads of single, compound refracting, and compound reflecting microscopes. The theory of the *single microscope* may be thus explained: We all know that at a small distance we see more distinctly than at a large. If we look at two men, one 200 feet distant, the other 100 feet, the former will appear only one half the height of the latter, or the angle which the latter subtends to the eye of the observer will be twice that subtended by the former. Hence we must conclude that the nearer we can bring an object to the eye the larger it will appear. Now if, to render the parts of a minute object distinguishable, we bring it very near the eye, (suppose within one or two inches,) it will become very indistinct and confused, in consequence of the great divergence of the rays of light from the object, and the power of the crystalline lens of the eye not being sufficient to collect the rays whereby an image of the object may be formed on the retina at the proper distance on the back of the eye. Now, if we employ a single microscope, which consists of a convex lens, usually made of glass, (though any other transparent substance would have the same power in a greater or less degree,) and mounted in a brass setting, and place it between the object and the eye, the former being in the focus of the glass, the diverging rays from the object will be refracted and rendered parallel by the lens, and thus we shall obtain a distinct and near view of the object. The increase of apparent magnitude obtained by the employment of lenses is proportioned to the difference of the distance of an object from the lens and the distance when seen without its assistance. This latter distance, (the distance of distinct vision of minute objects with the naked eye,) varies in different persons, and at different periods of life. Some measure, therefore, must be assumed as a standard, before we can express the amplifying power of a lens, so as mutually to have the same idea of the magnitude of an object. Some authors adopt ten inches as the standard of the focus of the eye, under ordinary circumstances, and its decimal character makes it a convenient multiplier or divisor. With this decimal standard we can determine the magnifying power of lenses of any focal length, or formed of any substance (media). Thus, if we have a lens which requires for distinct vision the object to be one inch from its centre, (in a double convex,) we must divide the standard ten by one, which will give ten as the magnifying power. If the lens require the object to be $\frac{1}{25}$ of an inch distant, its magnifying power will be 250. We have called the magnifying power in the first instance ten, because the length of the object is increased ten times; but, as its breadth is also increased ten times, the real magnifying power of the lens is ten times ten, or 100. The common form of the magnifiers employed for microscopes is double convex, and they should be made as thin as possible; for the wandering or spreading out of the rays proceeding from an object when refracted by a lens with spherical surfaces, whereby an indistinctness is produced in its image, will be decreased as the square of the thickness of the lens employed, and the loss of light in passing through the lens is less in proportion as it is thin.

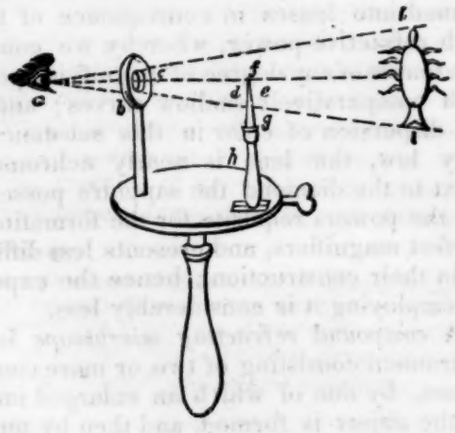
Within a few years diamonds have been formed into lenses in consequence of their high refractive power, whereby we can obtain lenses of any degree of magnifying power with comparatively shallow curves; and, as the dispersion of color in this substance is very low, the lens is nearly achromatic. Next to the diamond the sapphire possesses all the powers requisite for the formation of perfect magnifiers, and presents less difficulty in their construction; hence the expense of employing it is considerably less.

A *compound refracting microscope* is an instrument consisting of two or more convex lenses, by one of which an enlarged image of the object is formed, and then by means of the other, employed as an eye-glass, a magnified representation of the enlarged image is obtained. The distance at which the

two lenses of a compound microscope are placed from each other must always exceed the sum of their focal lengths, in order that the image may be formed by the object-glass in the anterior focus of the eye-glass. Compound microscopes have been constructed of almost all possible dimensions, from a few inches in length to twenty feet; but from experience it appears that whenever their magnitude is augmented beyond a certain point the effect is diminished, though we suppose the amplifying power of both microscopes the same.

The *solar microscope* consists of a common microscope connected with a reflector and condenser, the former being used to throw the sun's light on the latter, by which it is condensed to illuminate the object placed in its focus. This object is also in the focus of the microscopic lens on the other side of it, which transmits a magnified image of it to a wall or screen, (sometimes a combination of two magnifying lenses is used.) The magnifying power will be greater in proportion as the focal distance of the object-glass compared with the distance of the wall or screen from the object-glass is less. The principle of the *lucernal microscope* is the same, except that a lamp is used instead of the sun to illuminate the objects; this lamp is enclosed in a lantern, to screen the light from the observers.

Having thus given a general outline of the arrangement of the microscope in its various forms, it will now be advisable to furnish our readers with such graphic and descriptive particulars as will enable any ingenious workman, reading this article, in conjunction with our treatise on Optics, (which will be inserted hereafter,) to construct the instrument. To render this systematic and intelligible, it may be advisable to commence with the most simple form.



A very convenient form of microscope is shown in the preceding engraving, where *b* is a circular piece of brass or ivory, in the middle of which is a small hole, one-twentieth of an inch diameter: in this hole is fixed, with a wire, a small lens, whose focal distance is *c d*. At that point is placed a pair of pliers, *g h*, which may be adjusted by means of the sliding screw, as in the figure, and opened by means of two little studs. The object may be viewed with the eye placed in the other focus of the lens at *a*; and, according to the focal length of the lens, the object, *f*, will appear more or less magnified, as represented at *i l*. If the focal length be half or one-fourth of an inch, the length, surface, and bulk, of the object will be magnified in a similar proportion. This small instrument may be put into a case for the pocket. Those lenses whose focal lengths are three-tenths, four-tenths, and five-tenths of an inch, are the best for common use.

Since the nearer the eye can approach to an object the larger it appears, it is plain, a double and equally convex lens magnifies more than a plano-convex lens; because, if the sphere or convexity be the same, the focal length of the former is but half that of the latter; and, since the double convex consists of two segments of a sphere, the more an object is to be magnified, the greater must the convexity be, and therefore the smaller the sphere; till at last the utmost degree of magnifying power will require that these segments become hemispheres, and, consequently, the lens will be reduced to a perfect spherule, or very small sphere.

If the radius of the spherule be one-tenth of an inch, the eye will have distinct vision of an object by means thereof, at the distance of 1½ radius, (that is, three-twentieths of an inch,) and, as this is but the fortieth part of six inches, the length of an object will be magnified forty times, the surface 1600 times, and the solidity 64,000 times, by such a small sphere.

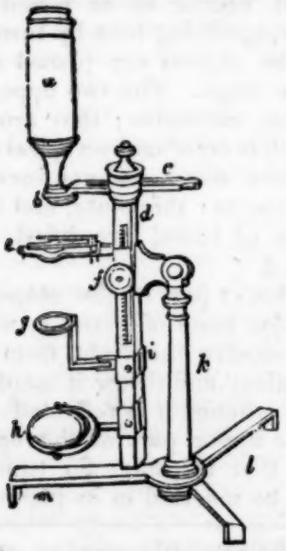
If the radius of a spherule be but one-twentieth of an inch, then will the eye have distinct vision of an object at the distance of three-fortieths of an inch, and as this is but the eightieth part of six inches, the length of objects will appear eighty times greater, the surface 6400 times, and the bulk 512,000 times greater, to the naked eye at six inches distance.

In using these spherule microscopes, the objects are to be placed in one focus and the eye in the other; and since the focus is so exceedingly near the glass, it is impossible to view any but pellucid bodies; for, if any opaque object were to be applied, the eye being, as it were, just on the spherule, would

entirely prevent any light falling on it, and it would be too obscure to be viewed.

To remedy this inconvenience, the focal length should be increased and a concave mirror substituted for the plate *b*. The object, *f*, being placed in the focus of the mirror, is illuminated by reflected light, and the most opaque insect may thus be seen with advantage to the naturalist. If the instrument thus arranged be directed towards the sun, the effect will be very materially improved; and when this cannot be accomplished, a sheet of white paper should be placed beneath the instrument.

The *compound microscope*, as made by Messrs. Jones, of Holborn, is shown in the engraving beneath. The body of the instrument, *a*, is screwed to the horizontal sliding arm, *c*. At *b* is a circular plate, containing a series of glasses, varying in their magnifying power. The objects to be magnified are placed in the stage, *e*, and the proper focus obtained by moving the rack at *f d*. The lens *g* is employed to concentrate the light of a lamp, or that of the sun, on the object to be examined. The reflector at *h* has two mirrors, the one concave, the other flat. The whole instrument is supported by the pillar, *k*, and the triangular stand, *l m*.

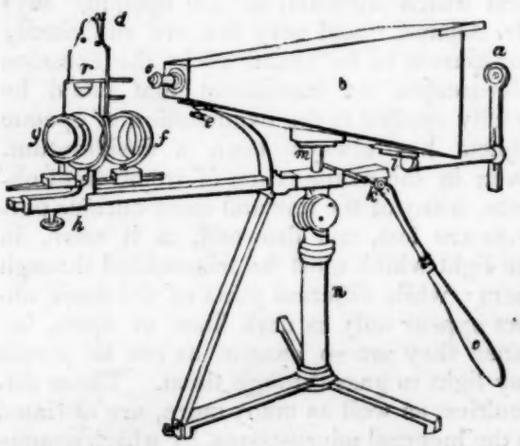


The great facility with which objects can be represented on paper, or a rough glass, in the camera obscura, and copies drawn from them by any person, though unskilled in drawing, evidently suggested the application of the microscope to this instrument. The greatest number of experiments that appear to have been made with this view, were by Mr. Martin and Mr. Adams, the former of whom frequently applied the microscope to the portable camera, and with much effect. But these instruments being found to answer only with the assistance of the sun, Mr. Adams directed his experiments to the constructior of an instrument of more extended utility, which could be equally employed in the day and by night. He accordingly succeeded so far as to produce, by candle-light, the images of objects refracted from a single magnifier, upon one or two large convex lenses (of about five inches, or upwards, in diameter,) at the end of a pyramidal-shaped box, in a very pleasing manner, so as to give opaque objects, as well as transparent ones, the utmost distinctness of representation; but still the light of a candle, or lamp, was found generally insufficient to throw the requisite degree of illumination on the objects. The invention of the Argand lamp offered a complete remedy for this defect, by the intensity and steadiness of its light.

The advantages of this excellently-conceived instrument are numerous and important. "As the far greater part of the objects which surround us are opaque," says Mr. Adams, "and very few are sufficiently transparent to be examined by the common microscopes, an instrument that could be readily applied to the examination of opaque objects has always been a desideratum. Even in the examination of transparent objects, many of the fine and more curious portions are lost, and drowned, as it were, in the light which must be transmitted through them; while different parts of the same object appear only as dark lines or spots, because they are so opaque as not to permit any light to pass through them. These difficulties, as well as many more, are obviated in the lucernal microscopes, by which opaque objects of various sizes may be seen with ease and distinctness, the beautiful colors with which most of them are adorned are rendered more brilliant, without changing in the least the real tint of the color, and the concave and convex parts retain also their proper form. The facility with which all opaque objects are applied to this instrument is another considerable advantage, and almost peculiar to itself: as the texture and configuration of the more tender parts are often hurt by previous preparation, every object may be examined by this instrument first as opaque, and afterwards (if the texture will admit of it) as transparent. The lucernal microscope does not in the least fatigue the eye; the object appears like nature itself, giving ease to the sight and pleasure to the mind: there is also, in the use of this instrument, no occasion to shut the eye which is not directed to the object. A further advantage peculiar to this microscope

is that by it the outlines of every object may be taken, even by those who are not accustomed to draw; while those who can draw well will receive great assistance, and execute their work with more accuracy, and in less time, than they would otherwise have been able to have performed it. Transparent objects as well as opaque may be copied in the same manner. The instrument may be used at any time of the day, but the best effect is by night; in which respect it has a superiority over the solar microscope, as that instrument can be used only when the sun shines.

"Transparent objects may be examined with the lucernal microscope in three or four different modes, from a blaze of light almost too great for the eye to bear to that which is perfectly easy to it; and, by the addition of a tin lantern to the apparatus, may be thrown on a screen, and exhibited at one view to a large company, as by the solar microscope."



In the above engraving we give a view of this instrument, mounted to examine opaque objects. *b* is a large mahogany pyramidal box, which forms the body of the microscope; it is supported firmly on the brass pillar, *n*, by means of the socket, *m*, and the curved piece, *e*. *a* is a guide for the eye, in order to direct it in the axis of the lenses; it consists of two brass tubes, *l*, one sliding within the other, and a vertical flat piece, at the top of which is the hole for the eye. The inner tube may be pulled out, or pushed in, to adjust it to the focus of the glasses. The vertical piece may be raised or depressed, that the hole through which the object is to be viewed may coincide with the centre of the field of view; it is moved by a milled screw, which could not be shown in this figure. At *l* is a dove-tailed piece of brass, made to receive the dove-tail at the end of the tubes, by which it is attached to the wooden box. The tubes may be removed from this box occasionally, for the convenience of packing it up in a less compass. At the small end of the cone is placed a tube, which carries the magnifiers, one of which is represented at *c*; the tube may be unscrewed occasionally from the wooden body. Beneath the cone is placed a long square bar, which passes through and carries the stage or frame that holds the objects; this bar may be moved backward or forward, in order to adjust it to the focus, by means of the pinion, *k*. A handle furnished with a universal joint, for more conveniently turning the pinion, is shown at *o*. When the handle is removed a nut may be used in its stead. The stage, *h*, for opaque objects, fits upon the bar by means of a socket, and is brought nearer to or removed further from the magnifying lens by turning the pinion, *k*; the objects are placed in the front side of the stage. The two upper pieces of brass, *r*, are moveable; they are fixed to a plate, which is acted on by a spiral spring, that presses them down, and confines the slider with the objects: this plate, and the two upper pieces of brass, are lifted up by the small nut, *d*.

At the lower part of the stage there is a semi-circular lump of glass, *g*, which is designed to receive the light from the lamp, and to collect and throw it on the concave mirror, *f*, whence it is reflected on the object. The upper part of the opaque stage takes out, that the stage for transparent objects may be inserted in its place.

On the Meteoric Phenomenon of November 13th, 1833. By D. A. Strong. To the Editor of the Mechanics' Magazine.

Sir,—I observed in my last Magazine something respecting the curious display of meteoric bodies on the morning of the 13th of November last, and wish you to state for me, that they all seemed to spring from a point about 30° south-east of the zenith, (as seen from this place,) and that this point remained stationary among the stars while I observed it. I first saw it about a quarter before six, though I was told by others it had been visible for three hours or more, and that the point from which all seemed to emanate had kept its place. However, I thought best to mark the place to determine the fact, and measure its height, should some other at a distance do the same. Accordingly I took a range from one building over the corner of another, marking the place. I also observed the stars nearest the point, but not being acquainted with many of them, I cannot tell their names. In about half an hour I looked at my range: the point had proceed-

ed considerably to the west, but kept its place with regard to the stars, or I should say, so appeared to me. I saw the train, which, like Aaron's rod, turned to a serpent; but should I draw it, I should make it shorter than in the engraving by one-third, and put the head on the other end.

I should have said the point was 30° from the zenith, not exactly south-east, but about 35° east of south, when I first observed it. This I determined by means of a sheet of tin, on which I marked a quarter circle, suspending a bullet by a hair for a plumb. It can be relied on as within a degree of the truth in the first arc or disc from the zenith, but of the other I am not so sure, as I took it from the corner of a street. You must excuse imperfections, as I am not in the habit of writing, and like many other young mechanics, have little of the philosopher about me; I will try, however, to have these bearings taken exactly, as the range remains marked; in the mean time I remain yours, &c. D. A. Strong.

Buffalo, Dec. 14, 1833.

The Meteoric Phenomenon on 13th November, 1833—Keeping Diaries or Daily Journals.

By Senex. [From the New-York Farmer.]

Mr. Editor,—The brilliant appearances which took place on the 13th of the present month appear, by the various accounts, to have been observed from Florida to Canada. I have expected that some speculations on the causes or probable effects of so singular a phenomenon might appear in the public papers, but as yet have been disappointed; nor can I pretend to throw any light on the subject, being quite unlearned in matters of this kind. Reading these accounts, however, brought to my recollection a similar appearance which took place in Scotland many years ago, and which I had marked in my daily journal at the time. On looking into the abstract of that for 1779, I find the following noted: "On the morning of the 13th November, from 5 to 8 o'clock, a great many meteors or balls of fire were seen in the air, breaking out with a great flash, which was succeeded by a long streak of light, something like the aurora borealis; and, in the intervals between the larger flashes, a vast number of the small meteors, commonly called falling or shot stars. Many people dreaded that these meteors portended no good; but they were mistaken. On the afternoon of the 13th was indeed a very heavy rain, but it was succeeded by several weeks of mild, calm weather, which gave many people an opportunity to finish their shearing, but was extremely against keeping it in the stack, the greater part of the ricks being obliged to be twice turned, though all built with air vents."

In looking over the journal before mentioned, I could not but remark the similarity of that season to the present. That of 1799, spring, summer, and autumn, was one of the coldest and wettest on record; the crop neither filled nor ripened as usual, and the harvest was not finished in the higher and northern districts of Scotland until the month of December. The season of 1833 has been in many respects similar; although the crops, with the exception of Indian corn, have not suffered like those of Scotland in 1799, yet the season has undoubtedly been colder and wetter than the average of seasons in this country. It may therefore be presumed that the phenomena in question have been produced by similar states of the atmosphere, resulting from a long tract of cold and wet weather. It does, however, appear somewhat wonderful that they should take place on the same day and hour of the year in both instances.

Philosophers may perhaps account for this phenomenon, and explain its causes in a satisfactory manner. It is however scarcely probable that any well-founded opinion can be formed as to its future effects on the weather or season; or whether it may have any influence whatever in that way.

I find by these journals that the winter of 1800 was one of the most severe that had happened for many years. A heavy fall of snow commenced the 2d January, which covered the ground above two feet deep, and remained until the first week of March, a thing very uncommon in any part of Britain.

I think it rather improbable that the present winter may prove a severe one, because we have had three very severe in succession, with colder and wetter summers than ordinary between. The present winter has however commenced earlier than usual; the snow lies at present about nine inches deep here, and has done so since the 25th. We have also heard of it two feet deep in some parts of this State. If it should prove uncommonly severe, it might be considered as a singular coincidence, yet may have no connection with the phenomenon in question, or it may, for aught I know.

I shall finish this communication, already much longer than I intended, by recommending to your juvenile readers, commencing farming operations, the propriety and pleasure of keeping a daily journal. I can, from forty years' experience, say that this practice will be found both very useful and agreeable; with me it has long become a habit, which it would be difficult to give up. Be

sides the facts and observations regarding the farm and garden which it contains, the journal is often referred to for ascertaining facts, dates, and domestic occurrences, regarding which doubt or dispute happens to arise. I can also add, that looking back sometimes into its pages has not unfrequently afforded me pleasure by recalling many agreeable recollections of past scenes, and of old and dear friends, many of whom have left the stage of life. And let it not be supposed that the keeping of a journal is to cost much either of time or trouble: three minutes each evening, and from three to six lines of an octavo page, may be stated as quite sufficient for the average of the year. It is also a very agreeable amusement, as well as very useful, to make an abstract of this journal once a year; this affords a concise history of the farm, and the operations and improvements that have been made from time to time, which will be found more and more interesting to the owner the longer it is continued,—the weather, seasons, experiments, facts and observations of every description too various to be enumerated.

SENEX.

Saratoga County, 30th Nov., 1833.

METEOROLOGICAL RECORD, KEPT IN THE CITY OF NEW-YORK,

From the 10th to the 31st of December, 1833, inclusive.

[Prepared expressly for the Mechanics' Magazine and Register of Inventions and Improvements.]

Date.	*Hours.*	*Thermometr.*	*Barometer.*	*Winds.*	*Strength of Wind.*	*Clouds from what direction.*	*Weather.*
Dec'r 10..	6 a. m.	36	30.00	SW by W	fresh	WSW / WNW	fair
	10	40	30.01	WSW—WNW	..	.. / ..	cloudy from WNW
	2 p. m.	40	30.02	WNW—NW	stormy	WNW	..
	6	39	30.10	NW	fresh	..	..
	10	38	30.15	..	..	..	..
" 11..	6 a. m.	36	30.16	NNW	..	NW	fair
	10	38	30.18	..	moderate	W by S / NNW	..
	2 p. m.	41	30.11	..	..	W by S	.. haze bank at W
	6	37	30.13	..	..	..	hazy
	10	34	30.14	..	..	..	.. —fair
" 12..	6 a. m.	26	30.20	N by W	..	WSW	fair
	10	28	30.23	..	..	..	..
	2 p. m.	32	30.20	NNW	..		clear
	6	31	30.24	..	..		..
	10	26	30.29	..	..		..
" 13..	6 a. m.	22	30.34	..	light		..
	10	26	30.35	..	..		.
	2 p. m.	32	30.29	NE—SE	faint		..
	6	30	30.30	NE	..		..
	10	26	30.31	..			..
" 14..	6 a. m.	22	30.28	..	mod.-fresh	W by S / NE	cloudy
	10	23	30.28	NE by E	fresh	.. / NE by E	..
	2 p. m.	27	30.14	ENE	strong-gale	ENE	..
	6	31	30.05	..	gale	..	.. —snowy
	10	31	29.93	..	.. —strong		.. —snow
" 15..	6 a. m.	30	29.88	N by E	strong		snow
	10	29	29.93	N	fresh		.. cloudy
	2 p. m.	31	29.99	..	..	N	cloudy
	6	30	30.09	N by W	moderate	NNW	..
	10	29	30.15	..	..		hazy
" 16..	6 a. m.	27	30.25	NNE	..	ENE	cloudy
	10	30	30.27	NE—ENE	..	..	..
	2 p. m.	35	30.24	ENE	..	..	..
	6	34	30.20	..	fresh	..	..
	10	34	30.13	.	strong-gale	..	.. —rainy
" 17..	6 a. m.	39	29.72	..	..*	..	rainy
	10	40	29.63	..—E	heavy gale†	..	rain
	2 p. m.	43	29.50	NE by E	..—mod.	..	.. —cloudy —rainy —rain
	6	42	29.57	..	..	..	..
	10	39	29.60	..	..		cloudy
" 18..	6 a. m.	39	29.63	..	..		..
	10	40	29.67	..	..	NE	..
	2 p. m.	41	29.72	NNE	fresh	..	..
	6	37	29.80	..	..	..	..
	10	35	29.91	..	..	..	..
" 19..	6 a. m.	32	30.00	N by E	moderate	NNE	fair
	10	34	30.18	NNE	..	..	..
	2 p. m.	36	30.19	N by E	..	N by E	..
	6	32	30.24	..	..		clear
	10	29	30.27	..	..		.
" 20..	6 a. m.	24	30.31	N by W	.		..
	10	27	30.36	N	..		..

CITY OF NEW-YORK—CONTINUED.

Date.	*Hours.*	*Thermometr.*	*Barometer.*	*Winds.*	*Strength of Wind.*	*Clouds from what direction.*	*Weather.*
Dec. 20..	2 p. m.	32	30.30	N	moderate		clear
	6	31	30.30	..	calm		..
	10	27	39.32	..	..		..
" 21..	6 a. m.	25	30.28	N by E	light	WSW	fair
	10	29	30.30	..	..	..	..
	2 p. m.	36	30.25	SW—WNW	faint	..	..
	6	34	30.23	S westerly	..	..	cloudy —rain and sleet
	10	34	30.20		..	..	rainy—moon visible at times
" 22..	6 a. m.	34	30.10	NNW	..	..	fair
	10	36	30.12	NW	moderate	..—WNW	..
	2 p. m.	40	30.11	..	..	WNW	..
	6	37	30.20	..			clear
	10	35	30.23		calm		..
" 23..	6 a. m.	34	30.25	NNE	faint	W by S	fair
	10	36	30.28	..	..	..	..
	2 p. m.	37	30.24	..	..	..	cloudy
	6	36	30.20	..	..	..	..
	10	36	30.10	..	..		rainy
" 24..	6 a. m.	40	29.82	NE	strong	NE	..
	10	39	29.86	NNE—N	..—fresh	..	..
	2 p. m.	40	29.85	NNW	fresh	WSW / NNW	cloudy —fair
	6	39	29.88	..	moderate		..
	10	39	29.88	..			..
" 25..	6 a. m.	38	29.78		calm		.. and foggy
	10	39	29.77	NE	moderate		rainy
	2 p. m.	40	29.60	NNE—N	..		rain —snow and rain
	6	38	29.63	NNW	..		..
	10	36	29.68				rainy
" 26..	6 a. m.	38	29.97	WNW	fresh	SW / NNW	fair
	10	41	30.03	..—W by S	..		..
	2 p. m.	39	30.10	W by N	..	W by N	..
	6	35	30.11	W by S—WSW	..		clear
	10	34	30.11	WSW	..		..
" 27..	6 a. m.	32	30.10	W by N	.	..	fair
	10	33	30.11	WNW-W by N	..	..	..
	2 p. m.	34	30.10	W by N	..	..	..
	6	31	30.09	..	..	WNW	..
	10	30	30.09	..	..	..	..
" 28..	6 a. m.	27	30.05	WSW	..	WSW	..
	10	31	30.10	..	..	WNW / WSW	..
	2 p. m.	33	30.08	W by S	..	W by S	cloudy
	6	33	30.04	..	moderate	..	..
	10	33	30.06	..	..	..	..
" 29..	6 a. m.	35	30.14	..	..	W by N	fair and pleasant
	10	37	30.19	..—W by N	..	..	..
	2 p. m.	41	30.20	..—W by S	..	WSW / N	..
	6	36	30.27	WSW	light		..
	10	34	30.30		..		..
" 30..	6 a. m.	33	30.28	ENE	..		cloudy
	10	35	30.35	..	..	S	..
	2 p. m.	36	30.25	..	..	..	rainy
	6	39	30.21	..	faint		..
	10	41	30.17	..	..		..
" 31..	6 a. m.	39	30.02	NNE—N by E	..		cloudy and foggy
	10	41	30.04	N-NNW-W by S	..	WSW	..
	2 p. m.	43	29.96	WSW	moderate	..	fair
	6	42	29 93	..	..	..	..
	10	39	29.96	..	..	..	cloudy

In December, the observations of winds from the North-Eastern quarter, were 79¼—from the South-Eastern, 1—from the South-Western, 23—from the North-Western, 43¼.

The observations of the direction of clouds or higher currents, for the same month, were as follows: From the North-Eastern quarter, 28—from the South-Eastern, 1—from the South-Western, 53¼—from the North-Western, 25¼.

Maximum of the barometer 30.50 in.—Minimum, 29.50 in.—Range, 1. in.

* The snow storm of the 14th commenced at Baltimore at half past eleven on Saturday morning, and at Philadelphia at 4 o'clock in the afternoon, and continued about the same length of time as here.

† The storm of the 17th, as well as that of the preceding Saturday, commenced somewhat earlier at the south and later at the eastward than usual; or, in other words, the progress of these two storms from south-west towards the north-east was *slower* than the average of other storms. The storm of the 17th is said to have been near twenty-four hours in travelling from New-York to Portland.

The common notion that the violent westerly wind which commonly succeeds an easterly gale is an opposing or antagonist wind, forcing back the easterly gale, is disproved by the facts attending the gale of the 17th, which, in this part of the country, exhibited no change to the westward—the wind continuing to blow from the north-eastern quarter till long after the gale had passed beyond the eastern limits of the United States. Such facts can be satisfactorily accounted for only by admitting the circuitous or whirlwind character of these storms.

	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	MOON'S PHASES.				
Janu'ry				1	2	3	4	3d Q.	2	11	17	M
	5	6	7	8	9	10	11	New	9	6	14	E
	12	13	14	15	16	17	18	1st Q.	17	9	46	E
	19	20	21	22	23	24	25	Full	25	5	17	M
	26	27	28	29	30	31		3d Q.	31	8	20	E
Feb'ry							1					
	2	3	4	5	6	7	8	New	8	0	5	E
	9	10	11	12	13	14	15	1st Q.	16	4	44	E
	16	17	18	19	20	21	22	Full	23	4	5	E
	23	24	25	26	27	28						
March							1					
	2	3	4	5	6	7	8	3d Q.	2	7	21	M
	9	10	11	12	13	14	15	New	10	6	22	M
	16	17	18	19	20	21	22	1st Q.	18	8	5	M
	23	24	25	26	27	28	29	Full	25	1	20	M
	30	31						3d Q.	31	8	32	E
April			1	2	3	4	5					
	6	7	8	9	10	11	12	New	8	11	46	E
	13	14	15	16	17	18	19	1st Q.	16	7	21	E
	20	21	22	23	24	25	26	Full	23	9	42	M
	27	28	29	30				3d Q.	30	11	38	M
May					1	2	3					
	4	5	6	7	8	9	10	New	8	3	28	E
	11	12	13	14	15	16	17	1st Q.	16	2	59	M
	18	19	20	21	22	23	24	Full	22	6	7	E
	25	26	27	28	29	30	31	3d Q.	30	4	0	M
June	1	2	3	4	5	6	7					
	8	9	10	11	12	13	14	New	7	5	0	E
	15	16	17	18	19	20	21	1st Q.	14	8	6	M
	22	23	24	25	26	27	28	Full	21	3	26	M
	29	30						3d Q.	28	9	3	E
July			1	2	3	4	5					
	6	7	8	9	10	11	12	New	6	4	17	E
	13	14	15	16	17	18	19	1st Q.	13	0	19	E
	20	21	22	23	24	25	26	Full	20	2	22	E
	27	28	29	30	31			3d Q.	28	2	13	M
August						1	2					
	3	4	5	6	7	8	9	New	5	1	38	M
	10	11	12	13	14	15	16	1st Q.	11	5	17	E
	17	18	19	20	21	22	23	Full	19	3	17	M
	24	25	26	27	28	29	30	3d Q.	27	6	52	M
	31											
Sept'br		1	2	3	4	5	6	New	3	9	53	M
	7	8	9	10	11	12	13	1st Q.	10	0	32	M
	14	15	16	17	18	19	20	Full	17	6	24	E
	21	22	23	24	25	26	27	3d Q.	25	10	10	E
	28	29	30									
Octob'r				1	2	3	4	New	2	6	4	E
	5	6	7	8	9	10	11	1st Q.	9	11	7	M
	12	13	14	15	16	17	18	Full	17	11	32	M
	19	20	21	22	23	24	25	3d Q.	25	11	31	M
	26	27	28	29	30	31						
Nov'br							1	New	1	3	11	M
	2	3	4	5	6	7	8	1st Q.	8	1	35	M
	9	10	11	12	13	14	15	Full	16	5	54	M
	16	17	18	19	20	21	22	3d Q.	23	10	38	E
	23	24	25	26	27	28	29	New	30	1	51	E
	30											
Dec'br		1	2	3	4	5	6	1st Q.	7	7	47	E
	7	8	9	10	11	12	13	Full	15	11	58	E
	14	15	16	17	18	19	20	3d Q.	23	7	52	M
	21	22	23	24	25	26	27	New	30	2	16	M
	28	29	30	31								

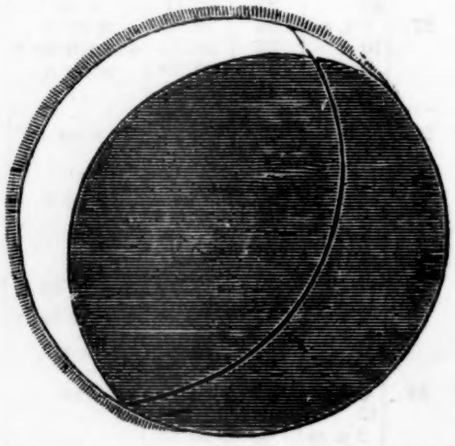
SOLAR AND LUNAR ECLIPSES IN THE YEAR 1834.—*First*, a small eclipse of the sun, on the 7th day of June, at 5 h. 2 m., invisible at New-York.

Second.—A total eclipse of the moon on the 21st day of June, in the morning, visible at New-York, as follows:

Beginning of the eclipse, at 1 h. 58 m.
Beginning of the total darkness, at 3 h. 1 m.
Middle of the eclipse, at 3 h. 43 m.
Ecliptical conjunction, at 3 h. 46 m.
End of total darkness, at 4 h. 25 m.
End of the eclipse, at 5 h. 28 m.
Digits eclipsed, 17¾ from the south side of the earth's shadow.

Third.—A large eclipse of the sun on the 30th of November, in the afternoon, visible at New-York, as follows:

Beginning of the eclipse, at 1 h. 6 m.
Greatest obscuration, at 2 h. 29 m.
Apparent conjunction, at 2 h. 30 m.
End of the eclipse, at 3h. 47 m.
Digits eclipsed, 10° 36′ on the southern limb of the sun, as represented in the following figure; the dark curved line represents the moon's centre across the sun from west to east.



The sun will be centrally and totally eclipsed on the meridian in latitude 40° 16′ north, and longitude 23° 33′ west from New-York.

The sun will be totally eclipsed at Charleston, South Carolina, and at Augusta, in Georgia, and many other places in the states of South Carolina, Georgia, Alabama, Tennessee, and Missouri, &c.

Fourth.—Of the moon, on the 15th day of December, in the evening, visible as follows at New-York:

Beginning of the eclipse, at 11 h. 4 m.
Middle of the eclipse, at 0 h. 20 m.
End of the eclipse, at 1 h. 30 m.
Digits eclipsed 7° 40′ on the moon's southerly limb.